## Khan Math 41 practices

## Solving linear equations

1. Solve for $k$ :
$k+22=29$
$k=$

Correct answer: 7 Difficulty level: 1
2. Solve for $n$ :
$-8+n=23$
$n=$

Correct answer: 31 Difficulty level: 1
3. Solve for $x$ :
$x-9=1$
$x=$

Correct answer: 10 Difficulty level: 1
4. Solve for $n$ :
$18=n-18$
$n=$

Correct answer: 36 Difficulty level: 1
5. Solve for $k$ :
$k+10=27$
$k=$

Correct answer: 17 Difficulty level: 1
6. Solve for $t$ :
$t+25=26$
$t=$

Correct answer: 1 Difficulty level: 1
7. Solve for $k$ :
$-30+k=22$
$k=$

Correct answer: 52 Difficulty level: 1
8. Solve for $k$ :
$19=14+k$
$k=$

Correct answer: 5 Difficulty level: 1
9. Solve for $q$ :
$3=-8+q$
$q=$

Correct answer: 11 Difficulty level: 1
10. Solve for $p$ :
$10=-19+p$
$p=$

Correct answer: 29 Difficulty level: 1
11. Solve for $r$ :
$-12+r=7$
$r=$

Correct answer: 19 Difficulty level: 1
12. Solve for p :
$p+12=30$
$\mathrm{p}=$

Correct answer: 18 Difficulty level: 1
13. Solve for p :
$\mathrm{p}-18=3$
$\mathrm{p}=$

Correct answer: 21 Difficulty level: 1
14. Solve for k :
$30=k+23$
$\mathrm{k}=$

Correct answer: 7 Difficulty level: 1
15. Solve for y :
$25=-14+y$
$y=$

Correct answer: 39 Difficulty level: 1
16. Solve for r :
$20=r+11$
$\mathrm{r}=$

Correct answer: 9 Difficulty level: 1
17. Solve for $z$ :
$-26+z=15$
$\mathrm{z}=$

Correct answer: 41 Difficulty level: 1
18. Solve for p :
$29=p+20$
$\mathrm{p}=$

Correct answer: 9 Difficulty level: 1
19. Solve for y :
$24=y+19$
$y=$

Correct answer: 5 Difficulty level: 1
20. Solve for n :
$27=15+n$
$\mathrm{n}=$

Correct answer: 12 Difficulty level: 1
21. Solve for k :
$2=-30+\mathrm{k}$
$\mathrm{k}=$

Correct answer: 32 Difficulty level: 1
22. Solve for n :
$19+n=30$
$\mathrm{n}=$

Correct answer: 11 Difficulty level: 1
23. Solve for k :
$18+\mathrm{k}=30$
$\mathrm{k}=$

Correct answer: 12 Difficulty level: 1
24. Solve for r :
$25=7+r$
r $=$

Correct answer: 18 Difficulty level: 1
25. Solve for p :
$2=-1+p$
$\mathrm{p}=$

Correct answer: 3 Difficulty level: 1
26. Solve for r :
$17=r+10$
$\mathrm{r}=$

Correct answer: 7 Difficulty level: 1
27. $12 s \leq 4(s-2)$

Which of the following best describes the solutions to the inequality shown above?
A. $s \leq-1$
B. $\mathrm{s} \leq-\frac{2}{3}$
C. $s \geq-\frac{1}{4}$
D. $s \geq 8$

Correct answer: A Difficulty level: 2
28. $4 c+5<4 c+3$

Which of the following best describes the solutions to the inequality shown above?
A. All real numbers
B. $\mathrm{c}<\frac{1}{2}$
C. $\mathrm{c}>\frac{1}{4}$
D. No solution

Correct answer: D Difficulty level: 2
29. If $9 \geq 4 x+1$, which inequality represents the possible range of values of $12 x+3$ ?
A. $12 x+3 \geq 17$
B. $12 x+3 \leq 17$
C. $12 x+3 \geq 27$
D. $12 x+3 \leq 27$

Correct answer: D Difficulty level: 2
30. $6=-s+77$

Given the above equation, what is the value of $1+5(77-s)$ ?
A. -739
B. -29
C. 31
D. 741

Correct answer: C Difficulty level: 2
31. If $16-7 w=w+14-6 w$, what is the value of $w-1$ ?
A. $w-1=-2$
B. $w-1=0$
C. $w-1=1$
D. $w-1=-3$

Correct answer: B Difficulty level: 2
32. If $\frac{1}{2}+\frac{2}{5} s=s-\frac{3}{4}$, what is the value of $s$ ?
A. $s=\frac{3}{4}$
B. $\mathrm{s}=\frac{25}{12}$
C. $s=-\frac{25}{12}$
D. $s=-\frac{3}{4}$

Correct answer: B Difficulty level: 2
33. $10(23+7)=100 \ell+100 \ell$

What is the value of $\ell$ in the equation above?

Correct answer: 3/2 Difficulty level: 2
34. $-p+60=-h+10000$

In the equation above, $h$ is a constant. If $p=10$ is a solution to the equation, what is the value of $h$ ?

Correct answer: 9950 Difficulty level: 2
35. $15 x-3=9 x+1$

Which of the following is the solution to the equation shown above?
A. $x=\frac{1}{6}$
B. $x=-\frac{2}{3}$
C. $x=\frac{2}{3}$
D. $x=1$

Correct answer: C Difficulty level: 2
36. $4+5 m=4 m+1+m$

Which of the following best describes the solution set to the equation shown above?
A. The equation has exactly one solution, $\mathrm{m}=0$.
B. The equation has exactly one solution, $\mathrm{m}=1$.
C. The equation has no solutions.
D. The equation has infinitely many solutions.

Correct answer: C Difficulty level: 2
37. If $15 b x-20>35$, where b is a positive constant, what is the possible range of values of 4-3bx?
A. Any value less than -7
B. Any value greater than -7
C. Any value less than $-\frac{11}{3 b x}$
D. Any value greater than $\frac{11}{3 b x}$

Correct answer: A Difficulty level: 2
38. If $-k+78=98-20$, then what is the value of $k$ ?

Correct answer: $0 \quad$ Difficulty level: 3
39. $\frac{2(4 p+1)}{5} \leq \frac{3+12 p}{4}$

Which of the following best describes the solutions to the inequality shown above?
A. $p \leq-\frac{13}{7}$
B. $p \geq-\frac{13}{7}$
C. $p \leq-\frac{1}{4}$
D. $p \geq-\frac{1}{4}$

Correct answer: D Difficulty level: 3
40. $-4+b x=2 x+3(x+1)$

In the equation shown above, $b$ is a constant. For what value of $b$ does the equation have no solutions?
A. 3
B. 4
C. 5
D. 6

Correct answer: 5 Difficulty level: 3
41. $\frac{3}{2} q \leq \frac{9}{2} q-18$

Which of the following best describes the solutions to the inequality shown above?
A. $q \leq 3$
B. $q \geq 3$
C. $q \leq 6$
D. $q \geq 6$

Correct answer: D Difficulty level: 3
42. If $9<15 \mathrm{mx}-8<27$, where $m$ is a positive constant, what is the possible range of values of $\frac{8}{3}-5 m x$ ?
A. Any value greater than -3 or less than -9
B. Any value greater than -9 and less than -3
C. Any value greater than $-\frac{7}{3 m}$ or less than $-\frac{17}{15 m}$
D. Any value greater than $-\frac{17}{15 m}$ and less than $-\frac{7}{3 m}$

Correct answer: B Difficulty level: 3
43. $-3(x+3)-8=6-4 x$

Which of the following is the solution to the equation shown above?
A. $x=17$
B. $x=-23$
C. $x=23$
D. $x=11$

Correct answer: C Difficulty level: 3
44. If $3(r+300)=6$, then what is the value of $r+300-2$ ?

Correct answer: 0 Difficulty level: 3
45. $3(t+1)=-\frac{1}{2}-5 t$

Which of the following best describes the solution set to the equation shown above?
A. The equation has no solutions.
B. The equation has exactly one solution, $t=-\frac{7}{16}$
C. The equation has exactly one solution, $\mathrm{t}=-\frac{7}{4}$
D. The equation has infinitely many solutions.

Correct answer: B Difficulty level: 3
46. If $5<2 x+3<11$, what is the possible range of values of $-4 x-6$ ?
A. Any value greater than -10 or less than -22
B. Any value greater than -22 and less than -10
C. Any value greater than 1 and less than 4
D. Any value greater than 4 or less than 1

Correct answer: B Difficulty level: 3
47. $4-\frac{1}{3} z=-7 z+6$

Which of the following is the solution to the equation shown above?
A. $\mathrm{z}=\frac{3}{10}$
B. $\mathrm{z}=-\frac{3}{10}$
C. $\mathrm{z}=\frac{20}{3}$
D. $z=\frac{20}{6}$

Correct answer: A Difficulty level: 3
48. If $153=2(z+z) n$, then what is the value of $2 n(2 z)-193$ ?
A. -113
B. -40
C. 40
D. 113

Correct answer: B Difficulty level: 3
49. $4|6+2 s|-27 \leq-3$

Which of the following best describes the solutions to the inequality shown above?
A. $-24 \leq \mathrm{s} \leq 0$
B. $-6 \leq \mathrm{s} \leq 0$
C. $s \leq 0$ or $s \geq 3$
D. No solution

Correct answer: B Difficulty level: 4
50. $4 x+1=-a x-4$

In the equation shown above, $a$ is a constant. Which of the following values of $a$ results in an equation with exactly one solution?
A. 4
B. -4
C. Neither value
D. Both values

Correct answer: A Difficulty level: 4
51. $4(80+n)=(3 k) n$

In the equation above, $k$ is a constant. For what value of $k$ are there no solutions to the equation?

Correct answer: $4 / 3$ Difficulty level: 4
52. $8-9(x+1)=a x+4$

In the equation shown above, $a$ is a constant. Which of the following values of $a$ results in an equation with exactly one solution?
A. 9
B. 8
C. Neither value
D. Both values

Correct answer: D Difficulty level: 4
53. $4(x-2)+x=a x-8$

In the equation shown above, $a$ is a constant. Which of the following values of $a$ results in an equation with exactly one solution?
A. 4
B. 5
C. Neither value
D. Both values

Correct answer: A Difficulty level: 4
54. $-2(x+2)=6-a x$

In the equation shown above, $a$ is a constant. Which of the following values of $a$ results in an equation with exactly one solution?
A. -2
B. 2
C. Neither value
D. Both values

Correct answer: A Difficulty level: 4
55. $2 x-1=-1+a x$

In the equation shown above, $a$ is a constant. Which of the following values of $a$ results in an equation with exactly one solution?
A. 2
B. 3
C. Neither value
D. Both values

Correct answer: B Difficulty level: 4
56. $4-3 y=6 y+4-9 y$

Which of the following best describes the solution set to the equation shown above?
A. The equation has no solutions.
B. The equation has exactly one solution, $\mathrm{y}=0$.
C. The equation has exactly one solution, $y=\frac{4}{3}$.
D. The equation has infinitely many solutions.

Correct answer: D Difficulty level: 4
57. $17+27=-7 w$

Given the above equation, what is the value of $10(-21 w+1)$ ?

Correct answer: 1330 Difficulty level: 4

## Part II Interpreting linear functions

1. 

The expression $\mathbf{1 . 0 8 s} \mathbf{+ 1 . 0 2 b}$ predict the end of year value of a financial portfolio where $\mathbf{s}$ is the value of stocks and $\mathbf{b}$ is the value of bonds in the portfolio at the beginning of the year.
What is the predicted end-of-year value of a portfolio that begins the year with $\mathbf{\$ 2 0 0}$ in the stocks and $\$ \mathbf{1 0 0}$ in bonds?
\$


Correct answer: 318 conclusions
2.


The graph above shows the results of a controlled experiment designed by a scientist to determine the effect of magnetic field strength on the growth of sunflower plants. $\mathbf{5 0 0}$ young sunflower plants were randomly assigned to the control or experimental group. In the control group, the scientist grew 250 sunflower plants under normal local geo-magnetic field conditions (30 microteslas). In the experimental group, the scientist grew $\mathbf{2 5 0}$ sunflower plants identically except under a lower geomagnetic field ( 20 microteslas). Based on the results of this experiment, which conclusion is NOT valid?
A. Sunflower plants grown under lower magnetic field conditions were more likely to weigh more than sunflower plants grown under normal magnetic field conditions.
B. There is evidence of an association between the strength of magnetic field and height in sunflower plants.
C. Sunflower plants grown under lower magnetic field conditions were more likely to be taller than sunflower plants grown under normal magnetic field conditions.
D. Members of the control group were more likely to grow to less than 100 inches than members of the experimental group.

## Correct answer: A Difficulty level: 2 Tag: Data collection and conclusions

3. 

A researcher wants to conduct a survey to gauge United States (U.S.) voters' opinions about the U.S. Congress. Which of the following should NOT be a component of this survey?
A. The researcher collects data from the survey takers.
B. The researcher analyzed data from the survey takers.
C. The researcher distributes the survey to 10,1000 randomly selected U.S. citizens aged 18 and older.
D. The researcher distributes the survey to 10,000 residents of a Washington D.C. neighborhood.

Correct answer: D Difficulty level: 2 Tag: Data collection and conclusions

## 4.

A scientist wants to collect data about the effects of gravity on the growth of soybean plants. To test her hypothesis that soybeans grow better in a zero-gravity setting, she randomly assigns the plants into one of two groups. The first group is grown in typical soybean growing conditions in a greenhouse on earth, and the second group is grown in a zero-gravity, yet otherwise identical greenhouse in a space station. Which of the following is the best description of the research design for this study?
A. Controlled experiment
B. Observational study
C. Sample survey
D. None of the above

Correct answer: A
Difficulty level: 2
Tag: Data collection and conclusions
5.

A researcher representing a city government wants to measure public opinion about recycling by asking $\mathbf{1 , 0 0 0}$ randomly selected residents a series of questions on the subject. Which of the following is the best description of the research design for this study?
A. Observational study
B. Sample survey
C. Controlled experiment
D. None of the above

Correct answer: B
Difficulty level: 2
Tag: Data collection and conclusions
6.

In order to determine whether children who have just watched cartoons will perform better on cognitive tasks than children who have not just watched cartoons, researchers randomly divided 60 preschoolers into three groups. For nine minutes, one group watched a rapid-paced cartoon,
one group watched a slower-paced educational program, and one group colored. They then administered standardized tests to determine the immediate impact of the children's previous nine minutes of activity. Which of the following is the best description of this type of research design?
A. An observational study, a study in which investigators observe subjects and measure variables of interest without assigning treatments to the subjects.
B. A controlled experiment, a study in which an investigator separates subjects into a control group that does not receive a treatment and an experimental group that receives a treatment, and then observes the effect of the treatment on the experimental group.
C. A sample survey, a study that obtains data from a subset of a population, usually through a questionnaire or interview, in order to estimate population attributes.
D. None of the above

Correct answer: B Difficulty level: 2

Tag: Data collection and conclusions
7.


A player at point A passes a ball to a player at point B . What is the distance, in yards, between point A and point B? ( Round your answer to the nearest tenth of a yard.)
$\square$
Correct answer: 45.5
Difficulty level: 2
Tag: Right triangle word problems

## 8.

Wanahton's rectangular baking sheet is $9 \frac{1}{2}$ inches (in) by $\mathbf{1 3} \mathrm{in}$. To the nearest inch, what is the longest breadstick Wanahton could bake on his baking sheet?
A. 13 in
B. 16 in
C. 124 in
D. 259 in

Correct answer: B
Difficulty level: 2
Tag: Right triangle word problems
9.


Due to weather, a barge captain decides to reach her destination in two legs: one due north and one due west. On a direct route, her destination is about $\mathbf{1 , 8 3 0}$ miles (mi) away; see the figure above. If after traveling $\mathbf{6 0 5} \mathbf{~ m i}$ due north the captain determines it is time to head due west, how many more miles are left in the trip? (Round your answer to the nearest mile.)


Correct answer: 1727
Difficulty level: 2
Tag: Right triangle word problems
10.

Abby is buying a widescreen TV that she will hang on the wall between two windows. The windows are 36 inches apart, and wide screen TVs are approximately twice as wide as they are tall. Of the following, which is the longest that the diagonal of a widescreen TV can measure and still fit between the windows?
A. 32 inches
B. 42 inches
C. 55 inches
D. 60 inches

## Correct answer: A

Difficulty level: 2

## Tag: Right triangle word problems

18
11.

Bilal was assembling a set of bunkbeds and wanted to make sure the support posts were perpendicular to the floor. He measured that the posts were $\mathbf{1 6 5}$ centimeters ( $\mathbf{c m}$ ) tall and $\mathbf{2 2 0} \mathbf{~ c m}$ apart. How long should the diagonal measurement be if the support posts are perpendicular to the floor?
A. 75 cm
B. 130 cm
C. 275 cm
D. 385 cm

Correct answer: C Difficulty level: $2 \quad$ Tag: Polynomial factors and graphs
12. $P(x)=2 x^{3}-18 x$

Given the polynomial function $\boldsymbol{P}$ defined above, what are its zeros?
A. $\{-9,-6,2,3\}$
B. $\{-9,0,2\}$
C. $\{-3.3\}$
D. $\{-3,0,3\}$

## Correct answer: D

Difficulty level: 2
Tag: Polynomial factors and graphs
13.


Which of the following gunctions could represent the graph at left in the $x y$-plane, where $y=P(x)$ ?
A. $P(x)=x^{2}+6 x+8$
B. $P(x)=x^{3}+6 x^{2}+8 x$
C. $P(x)=x^{2}-6 x+8$
D. $P(x)=x^{3}-6 x^{2}+8 x$

Correct answer: D
Difficulty level: 2
Tag: Polynomial factors and graphs
14. A polynomial has zeros at $-9,2$, and 0 . Which of the following could be the polynomial?
A. $x^{2}-7 x-18$
B. $x^{3}+7 x^{2}-18 x$
C. $x^{3}+8 x^{2}-11 x-18$
D. $x^{3}+6 x^{2}-5 x+18$

Correct answer: B
Difficulty level: 2
Tag: Polynomial factors and graphs
15. $(x-7)(x+5)(2 x-3)$

Given the polynomial above, what are its zeros?
A. $\{-7,5,-3\}$
B. $\{7,-5,3\}$
C. $\left\{-7,5,-\frac{3}{2}\right\}$
D. $\left\{7,-5, \frac{3}{2}\right\}$
16. $2(x+55)(x-17)$

Given the polynomial above, what are its zeros?
A. $x=-55$ and $x=17$
B. $x=-55, x=-2$, and $x=17$
C. $x=-17$ and $x=55$
D. $x=-17, x=2$, and $x=55$

Correct answer: A Difficulty level: 2
Tag: Polynomial factors and graphs
17. $0.2 \mathrm{~B}+0.1 \mathrm{~S}=\mathrm{C}$

Rhia is using the above equation to investigate the carbon footprint, C , in kilograms of carbon dioxide $\left(\mathrm{CO}_{2}\right)$ emissions, for her morning commute, during which S miles are by subway and B miles are by bus. How many kilograms of $\mathrm{CO}_{2}$ per mile does the bus portion contribute to Rhia's carbon footprint?


Correct answer: 0.2

## Difficulty level: 2

## 18. $V=2.5(6.4-t)$

Salma is filling her water jugs with spring water at the supermarket. The above equation gives the empty space in her jugs, V, in US gallons, after t minutes at a constant fill rate. How many minutes will it take to fill the jugs?


## Correct answer: 6.4 Difficulty level: 2

19. $\mathrm{T}=0.25 \mathrm{q}+87$

Manon's statistics professor puts a bonus question on every test, which adds $\mathbf{0 . 2 5}$ points to a student's overall grade at the end of the term. The above equation gives Manon's current overall grade, $\boldsymbol{T}$, after taking into account $\boldsymbol{q}$ extra credit questions answered correctly. What does the $\mathbf{8 7}$ mean in this equation?
A. Manon must get an $\mathbf{8 7}$ or above to pass.
B. Manon's average is an $\mathbf{8 7}$ before adding the extra credit.
C. After adding in her extra credit, Manon's average is an $\mathbf{8 7}$.
D. Manon's professor gave 87 opportunities for extra credit this term.

## Correct answer: B Difficulty level: 2

20. $\mathrm{T}=10 \mathrm{~m}+40$

Tim decides to cook a steak. The interior temperature, $\boldsymbol{T}$, of the steak, in degrees Fahrenheit( $\left.{ }^{\circ} F\right)$, after cooking for $m$ minutes is given in the equation above. What does the 10 mean in the equation?
A. The interior temperature is $10{ }^{\circ}$ when Tim starts cooking the steak.
B. The interior temperature of the steak increases by $10{ }^{\circ} F$ for every minute it is cooked.
C. The interior temperature of the steak decreases by $10{ }^{\circ} F$ for every minute it is cooked.
D. The interior temperature of the steak will increase a total of $\mathbf{1 0}{ }^{\circ} F$ while being cooked.

## Correct answer: B Difficulty level: 2

## 21. $5.5 \mathrm{~B}+4 \mathrm{R}=28$

The above equation models the cost if Amit picks B pounds of blueberries and R pounds of raspberries at a farm where blueberries cost $\$ 5.50$ per pound and raspberries cost $\$ 4.00$ per pound. According to the equation, how much does Amit spend in total on both types of berries?
A. $\$ 9.50$
B. $\$ 22.00$
C. $\$ 28.00$
D. $\$ 56.00$

Correct answer: C

## Difficulty level: 2

22. $g=15-\frac{m}{32}$

If Vera starts with a full tank of gas, the number of gallons of gas, $g$, left in the tank after driving $m$ mile is given by the equation above. When full, how many gallons of gas does Vera's tank hold?
A. 15 gallons
B. 17 gallons
C. 30 gallons
D. 32 gallons

Correct answer: A Difficulty level: 3
23.

Officials project that between 2010 and 2050, the Sub-Saharan African population will drastically change. The model below gives the projection of the population, $\boldsymbol{P}$, in thousands, with respect to time, $\boldsymbol{t}$ ( provided that 2010 is when $t=0$ ).

$$
P=175+\frac{11}{2} t
$$

What does the $\mathbf{1 7 5}$ mean in the equation?
A. In 2010, the population of Sub-Saharan African was 175 thousand.
B. In 2050, the population of Sub-Saharan African will be 175 thousand.
C. Between 2010 and 2050, the population of Sub-Saharan African will increase by 175
thousand.
D. Between 2010 and 2050, the population of Sub-Saharan African will decrease by 175 thousand.

## Correct answer: A Difficulty level: 3

24. $S=537.5-1.25 p$

An artist is carving chess pieces from a large piece of marble. After carving $p$ chess pieces, there are $S$ pounds of uncarved marble left. As the number of chess pieces carved increases, what happens to the weight of the uncarved marble?
A. There are 125 pounds left.
B. There are 537.5 pounds left.
C. The weight decreases.
D. The weight increases.

## Correct answer: C Difficulty level: 3

25. $W=-\frac{1}{2} m+16$

Henry's water bottle is leaking at a constant rate. The amount of water, $\boldsymbol{W}$, in ounces, that is left in the water bottle after leaking for $m$ minutes is given by the equation above. What does the $-\frac{1}{2}$ mean in the equation?
A. The water bottle loses 2 ounces of water per minute.
B. The water bottle loses $\frac{1}{2}$ an ounces of water per minute.
C. The water bottle has $\frac{1}{2}$ an ounces of water in it at the start.
D. $\frac{1}{2}$ of the water has leaked from the water bottle in one minte.

Correct answer: B Difficulty level: 3
26. $P=23+10(h-1)$

People start waiting in the line for the release of the newest cell phone at $5 \mathbf{a} . \mathrm{m}$. The equation below gives the number of people, $\boldsymbol{P}$, in line between the hours, h, of $\mathbf{6}$ a.m. and 11 a.m., when the doors open. Assume that $\mathbf{6} \mathbf{a . m}$. is when time $h=1$. What does the $\mathbf{2 3}$ mean in the equation above?
A. There are $\mathbf{2 3}$ people in line at $\mathbf{6}$ a.m.
B. After $\mathbf{1 0}$ hours, a total of $\mathbf{2 3}$ people will be in line.
C. Every hour between $5 \mathbf{a} . \mathrm{m}$. and $11 \mathrm{a} . \mathrm{m} ., 23$ more people get in line.
D. Every hour between $\mathbf{6}$ a.m. and $\mathbf{1 1}$ a.m., 23 more people get in line.

Correct answer: A
Difficulty level: 3
27. $S=40,000+500 \mathrm{c}$

Caden started a new job selling dental chairs. He earns a base salary plus a commission for every chair he sells. The equation above gives Caden's annual salary, $\boldsymbol{S}$, in dollars, after selling $\boldsymbol{c}$ dental chairs. Based on the equation above, what is Caden's base salary?
A. $\$ 39,500$
B. $\$ 40,000$
C. $\$ 40,500$
D. $\$ 50,000$

## Correct answer: B Difficulty level: 2

28. 

Anthropologists have noticed that they can predict the height of a human being based on the length of their femur. The relationship between the person's height, $\boldsymbol{H}$, in centimeters, and length of the femur, $\boldsymbol{f}$, in centimeters, can be modeled by the equation below.

$$
H=2.72 f+42.12
$$

One anthropologist found the femurs of two different people. One femur measured 22 centimeters and the other femur measured 23 centimeters. What is the difference in their heights?
A. 1 centimeter
B. 2.72 centimeters
C. 27.2 centimeters
D. 42.12 centimeters

Correct answer: B Difficulty level: 3
29. $d=1.06(212-t)$

A spacecraft heading for Pluto will take pictures of several other planets on its way. The above equation gives the distance, $\boldsymbol{d}$, in millions of kilometers, of the craft from its first photo opportunity with Mars in terms of the time, $\boldsymbol{t}$, in days. What is the meaning of the $\mathbf{2 1 2}$ in this equation?
A. The spacecraft travels 212 kilometers per day.
B. It will take the spacecraft $\mathbf{2 1 2}$ days to reach the Mars photo opportunity.
C. The spacecraft begins its journey $\mathbf{2 1 2}$ kilometers from the Mars photo opportunity.
D. After $\mathbf{2 1 2}$ days, the spacecraft will be within $\mathbf{1 . 0 6}$ kilometers of the Mars photo opportunity.

Correct answer: B
Difficulty level: 3
30. $35 A+28 P=250$

Vera is hiring entertainers for her charity event. She is using the equation above to determine the number of hours, $\boldsymbol{A}$ and $\boldsymbol{P}$, to hire a caricature artist and a face painter for, respectively, with a total budgeted cost of $\mathbf{\$ 2 5 0}$. The caricature artist charges $\mathbf{\$ 3 5}$ per hour and the face painter charges $\mathbf{\$ 2 8}$ per hour. What is the meaning of the $\mathbf{3 5 A}$ in this equation?
A. The caricature artist charges 35 A dollars per hour.
B. The caricature artist works for a minimum of 35 A hours in a week.
C. For the first 35 hours each week, the caricature artist makes A dollars.
D. The caricature artist charges a total of 35A dollars for A hours worked.

## Correct answer: D

Difficulty level: 3
31. $P=100 h-2,000$

It costs $\$ 2,000$ a month for Mia to rent space to run her law firm. She charges $\$ 100$ per hour for legal advice. The equation above gives Mia's profit, P , per month, after working h hour. How many hours does Mia have to work before she starts to make money each month?
A. 20 hours
B. 80 hoursO
C. 100hours
D. 200hours

Correct answer: A Difficulty level: 3
32. $C=1.5 b+67.5$

The total cost, C , in dollars, to produce b books is given by the equation below. What is the meaning of 1.5 in the equation?
A. 1.5 books will cost $\$ 67.50$ to produce.
B. It costs an extra $\$ 1.50$ for each book produced.
C. If you produce one book, you total cost will be $\$ 1.50$
D. There is a flat fee of $\$ 1.50$ to produce any number of books.

Correct answer: B Difficulty level: 4
33. $B=0.55 A$

Jing is making homemade peanut butter. The equation above shows the amount of peanut butter yielded, B, in cups, for A cups of peanuts. What percentage of the volume of peanuts is lost when processing them into peanut butter?
A. $0.55 \%$
B. $0.45 \%$
C. $55 \%$
D. $45 \%$

Correct answer: D

## Difficulty level: 4

34. $P=0.7 c$

A store is having a sale on every item purchased. Irina decides to take advantage of the sale and purchases a sweater. The equation that gives the after-sale price, $\boldsymbol{P}$, of Irina's sweater with an original cost, $\boldsymbol{c}$, is shown above. What percent off the original cost did Original cost did Irina save?
A. $3 \%$
B. $7 \%$
C. $30 \%$
D. $70 \%$

Correct answer: C Difficulty level: 4
35. $T=1200-0.06 c$

A print shop copies and prints documents in large volume for its customers. For a particular copy machine, the equation above gives the amount of toner, $\boldsymbol{T}$, in grams, left after making $\boldsymbol{c}$ copies.
How many grams of toner are used per copy?


## Correct answer: 0.06 Difficulty level: 4

36. $16 B+3.5 W=22$

Antoine bikes part of the way on a 22 mile trail and walks the rest of the way. If he spends $\mathbf{B}$ hours biking and $\mathbf{W}$ hours walking, the trip is modeled by the equation shown above. What is the meaning of the $\mathbf{1 6 B}$ in the equation?
A. Antoine travels a total of $\mathbf{1 6 B}$ miles.
B. Antoine bikes for a total of $\mathbf{1 6 B}$ miles.
C. Antoine bikes for 16B miles before starting his walk.
D. Antoine rides his bike at an average speed of $\mathbf{1 6 B}$ mile per hour.

Correct answer: C
Difficulty level: 4
37. $0.30 P+0.25 G=57$

A homeowner uses $\boldsymbol{G}$ hour of natural gas heat and $\boldsymbol{P}$ hours of heat from a pellet stove to heat her house one month, with a total of $\mathbf{5 7}$ therms of output. How many therms per hour does the pellet stove output?


Correct answer: 0.3 Difficulty level: 4
38. $C=40(5-S)$

After Hiro's family photo shoot the photographer sells the printed photos by the sheet. Hiro has a $\$ \mathbf{2 0 0}$ credit from a prior session, and the above equation gives the total credit left, $\boldsymbol{C}$, in dollars, if he buys $\boldsymbol{s}$ sheets. How many sheets can Hiro purchase with his credit?
A. 5sheets
B. 8sheets
C. 35 sheets
D. 200sheets

Correct answer: A Difficulty level: 4
39. $C=1.5 b+67.5$

The total cost, $\boldsymbol{C}$, in dollars, to produce $\boldsymbol{b}$ books is given by the equation below. What is the meaning of $\mathbf{1 . 5}$ in the equation?
A. 1.5 books will cost $\$ 67.50$ to produce.
B. It costs an extra $\$ 1.50$ for each book produced. This is the correct answer.
C. If you produce one book, you total cost will be $\$ 1.50$.
D. There is a flat fee of $\$ 1.50$ to produce any number of bool.

## Correct answer: B <br> Difficulty level: 4

## Part III linear equation word problem

1. If $\frac{1}{2}+4 x=-x+2$, what is the value of $x$ ?
A. $\mathrm{X}=\frac{3}{10}$
B. $X=\frac{1}{2}$
C. $X=\frac{5}{6}$
D. $\mathrm{X}=\frac{15}{2}$
correct answer: A difficult degree: 1
2. $8 x+5=b x-7$

In the equation shown above, $b$ is a constant. For what value of $b$ does the equation have no solutions?
A. -8
B. -7
C. 5
D. 8
correct answer: D difficult degree: 1
3. If $-8-8 y=6-2 y$, what is the value of $y$ ?
A. $Y=-\frac{3}{7}$
B. $Y=\frac{3}{7}$
C. $Y=\frac{7}{3}$
D. $Y=-\frac{7}{3}$
correct answer: D difficult degree: 1
4. $2\left|-\frac{v}{4}\right|+26<12$

Which of the following best describes the solutions to the inequality shown above?
A. $-7<7$
B. $-28<28$
C. No solution
D. All real numbers
5. $\frac{2}{3}-5 x=b x+\frac{1}{3}$

In the equation shown above, $b$ is $a$ constant. For what value of $b$ does the equation have no solutions?
A. 5
B. 0
C. -5
D. $\frac{2}{3}$
correct answer: C difficult degree: 1
6. Dimitri is helping to plan the school talent show. Each performer for the talent show has 6 minutes for his or her performance, which includes transition time between performances. If the introduction for the talent show is 24 minutes long and the show will last 150 minutes, how many different performances can the talent show accommodate?
A. 21
B. 24
C. 25
D. 29
correct answer: A difficult degree: 2
7. The property taxes in a town decrease as the distance from the local elementary school increases. The greatest property taxes are $4.5 \%$, and for every 10 miles from the school, property taxes decrease by 0.5 percentage points. If a house is directly east or west of the school and its property taxes are $3 \%$, what is the distance of that house from the school?
A. 10 miles
B. 20 miles
C. 30 miles
D. 40 miles
correct answer: C difficult degree: 2
8. Dalia is installing a tile floor in a rectangular room. Dalia has 152 tiles available to tile the room. If each row requires $9 \frac{1}{2}$ tiles, and 19 tiles break while Dalia is laying
the floor, how many full rows of tile can she install before running out of tiles?
A. 12
B. 14
C. 16
D. 18
correct answer: B difficult degree: 2
9. Phytoremediation is the use of plant growth to purify pollutants from soil, water, or air. Suppose that a crop of brake ferns can remove 15 milligrams (mg) per square meter of a particular pollutant from the soil in 20 weeks. After 20 weeks, the ferns are harvested and a new crop is planted. If cc represents the number of crops of brake ferns needed to phytoremediate soil contaminated with 170 mg per square meter of the pollutant down to healthy levels of 5 mg per square meter, which equation best models the situation?
A. $170-20 c=5$
B. $170+20 c=5$
C. $170-15 \mathrm{c}=5$
D. $170+20 c=5$
correct answer: C difficult degree: 2
10. One of the rules in a public speaking contest requires contestants to speak for as close to 5 minutes ( 300 seconds) as possible. Contestants lose 3 points for each second they speak either over or under 5 minutes. Which expression below can be used to determine the number of points a contestant loses if she speaks for xx seconds?
A. $3|x-300|$
B. $5|x-300|$
C. $3|x+300|$
D. $\frac{3}{5}|x+300|$
correct answer: A difficult degree: 2
11. Cara is hanging a poster that is 91 centimeters ( cm ) wide in her room. The center of the wall is 180 cm from the right end of the wall. If Cara hangs the poster so that the center of the poster is located at the center of the wall, how far will the left and right edges of the poster be from the right end of the wall?
A. 225.5 cm and 89 cm , respectively
B. 271.5 cm and 134.5 cm , respectively
C. 225.5 cm and 134.5 cm , respectively
D. 271 cm and 89 cm , respectively correct answer: C difficult degree: 2
12. Felipe is saving money for a class trip. He already has saved $\$ 250$ that he will put toward the trip. To save more money for the trip, Felipe gets a job where each month he can add $\$ 350$ to his savings for the trip. Let $m$ be the number of months that Felipe has worked at his new job. If Felipe needs to save $\$ 2700$ to go on the trip, which equation best models the situation?
A. $250 \mathrm{~m}-350=2700$
B. $250 \mathrm{~m}+350=2700$
C. $350 \mathrm{~m}-250=2700$
D. $350 \mathrm{~m}+250=2700$
correct answer: D difficult degree: 2
13. Camille and Hiroki have decided to start walking for exercise. Camille is going to walk 7 miles the first day and 3 miles each day after that. Hiroki is too busy to walk on the first 2 days, so he decides to walk 5 miles each day until he has walked the same number of miles as Camille. If Camille and Hiroki will have walked the same number of miles, how many days will Camille have walked?
A. 2
B. 3
C. 5
D. 7
correct answer: D difficult degree: 2
14. An art gallery displays a large painting in the center of a wall that is 24 feet ( ft ) wide. The painting is 10 ft wide. Which of the following equations can be used to find the distances, $x x$, in feet, from the left end of the wall to the edges of the painting?
A. $|x-10|=12$
B. $2|x-12|=10$
C. $2|x-10|=12$
D. $|x-12|=10$
correct answer: B difficult degree: 2
15. At the country fair, the operator of a game guesses a contestant's weight. For each pound the operator's guess differs from the contestant's weight, the contestant will receive \$3. If a contestant received \$15 when the operator guessed 120 pounds, what are the possible values for the weight of the contestant?
A. 105 and 115
B. 105 and 125
C. 115 and 125
D. 115 and 135
correct answer: C difficult degree: 2
16. A food truck owner has determined that her maximum revenue occurs when she sells 950 sandwiches per month. For every sandwich above or below 950 that she sells, her revenue decreases by $\$ 0.10$. Which of the following could be the number of sandwiches sold in a month if the owner's revenue decreased \$45 from the maximum? Round the answer to the nearest whole number.
A. $s=905$ or $s=995$
B. $s=946$ or $s=955$
C. $s=500$ or $s=1,400$
D. $s=500$ or $s=950$
correct answer: C difficult degree: 3
17. An ice cream truck owner has determined that his maximum revenue occurs when he sells 1,250 cones per month. For every cone above or below 1,250 that he sells, his revenue decreases by $\$ 0.15$. Which of the following equations can be used to find the possible numbers of cones, $c$, for which the revenue decreases $\$ 250$ from the maximum?
A. $15|c-250|=1,250$
B. $15|\mathrm{c}-1,250|=250$
C. $0.15|c-1,250|=250$
D. $0.15|c-250|=1,250$
correct answer: C difficult degree: 3
18. From 1980 to 2000 , the annual profit of a company was $\$ 625,000$ less $\$ 25,000$ times the number of years either before or after 1990. Which of the following equations below could be used to determine in which year, $x$, the profit was $\$ 550,000$ ?
A. $550-25|x-1990|=625$
B. $625-25|x-1990|=550$
C. $625+25|x-1990|=550$
D. $625+25|x+1990|=550$
correct answer: B difficult degree: 3
19. Each of the 18 tires of a fully loaded semi-truck is bearing approximately 3,300 pounds. The unloaded truck and trailer, with the driver aboard, weighs 30,000 pounds. The truck holds 26 pallets of cargo when it is fully loaded. What is the
approximate average weight of one pallet of cargo?
A. 1,131 pounds
B. 1,280 pounds
C. 1,633 pounds
D. 1,665 pounds correct answer: A difficult degree: 3
20. At the county fair, the operator of a game guesses a contestant's weight. For each pound the operator's guess differs from the contestant's weight, the contestant will receive $\$ 3$. A contestant weighing $x$ pounds received $\$ 15$ when the operator guessed 120 pounds. Which of the following equations could be used to solve for the weight of the contestant?
A. $3|x-15|=120$
B. $3|x-120|=15$
C. $15|x-120|=3$
D. $15|x-3|=120$
correct answer: B difficult degree: 3
21. Sam gives his little sister Lisa a 15 second (sec) head start in their 300 meter (m) race. During the race, Llsa runs at an average speed of $5 \mathrm{~m} / \mathrm{sec}$ and Sam runs at an average speed of $8 \mathrm{~m} / \mathrm{sec}$. Which of the following best approximates the number of seconds that Sam will run before he catches Lisa?
A. 5
B. 25
C. 40
D. 55
correct answer: B difficult degree: 3
22. A company's unit cost for producing $q$ units is a minimum when $q=80$ units are produced. The unit cost increases $\$ 7$ for every 10 units more or less than 80 produced. If the minimum unit cost is $\$ 5$, which of the following equations can be used to find the number of units, $q$, for which the unit cost is $\$ 8.25$ ?
A. $5+0.7|q-80|=8.25$
B. $0.7|\mathrm{q}-80|=8.25$
C. $5-0.7|\mathrm{q}-80|=8.25$
D. $-0.7|q-80|=8.25$
correct answer: A difficult degree: 3
23. A company has determined that its maximum profit occurs when it sells 10,000 units per month. For every 1,000 units more or less than 10,000 units that the
company sells, its profit decreases by $\$ 5,000$. Which of the following equations can be used to find the number of units, $q$, in thousands, for which the profit decreases $\$ 35,000$ from the maximum?
A. $10|q-35|=5$
B. $5|q-10|=35$
C. $35|q-10|=5$
D. $5|q-35|=10$
correct answer: B difficult degree: 3
24. Carlos shovels snow from driveways in his neighborhood. He charges $\$ 10$ for each regular driveway and he charges an extra $\$ 7.50$ for each large driveway that he shovels. After a snowstorm he shovels 3 fewer large driveways than regular driveways and makes $\$ 140$. How many regular driveways did Carlos shovel?
A. 3
B. 4
C. 7
D. 9
correct answer: C difficult degree: 3
25. A stack of 20 stainless steel sheets is supposed to be 40 millimeters (mm) thick. The allowable amount of variation in thickness (tolerance) is 0.08 mm for an individual sheet. Which of the following are the smallest and largest allowable thicknesses for a stack of 20 sheets?
A. 39.92 mm and 40.08 mm , respectively
B. 399.2 mm and 400.8 mm , respectively
C. 38.4 mm and 41.6 mm , respectively
D. 384 mm and 416 mm , respectively correct answer: C difficult degree: 3
26. A company that produces thumb drives has determined that its maximum profit occurs when it sells 5,000 units per month. For every 500 units above or below 5,000 the company sells, its profit decreases by $\$ 1,500$. Which of the following could be the number of units sold in a month if the company's profit decreased $\$ 12,000$ from the maximum? Round the answer to the nearest whole number.
A. 100 or 900 units
B. 1,000 or 9,000 units
C. 460 or 540 units
D. 4,600 or 5,400 units
correct answer: B difficult degree: 3
27. Rani is a real estate agent. For each house she sells, she pays $\$ 100$ in fees, but earns a commission of $1.8 \%$ of the selling price of the house. Rani's total profit from a particular house is $\$ 4,580$. If $p$ represents the selling price of the house, which equation best models the situation?
A. $0.018 \mathrm{p}-100=4580$
B. $0.018 \mathrm{p}+100=4580$
C. $(100-0.018) \mathrm{p}=4580$
D. $(100+0.018) p=4580$ correct answer: A difficult degree: 3
28. A rectangular garden has a length of 60 feet ( ft ), a width of wf , and a perimeter of 200 ft . Which of the following equations best models the garden's perimeter?
A. $60+w=200$
B. $60+2 w=200$
C. $120+w=200$
D. $120+2 w=200$
correct answer: D difficult degree: 3
29. A barber offers two options at his barbershop: a $\$ 15.00$ regular haircut and a $\$ 20.00$ deluxe haircut that includes a shave. On a certain day, the barber gave 3 fewer deluxe haircuts than he did regular haircuts, $h$, and earned $\$ 500.00$ in total from the two kinds of haircuts. Which of the following equations best models this situation?
A. $15.00 \mathrm{~h}+20.00(\mathrm{~h}-3)=500.00$
B. $15.00 \mathrm{~h}+20.00(\mathrm{~h}+3)=500.00$
C. $15.00(\mathrm{~h}-3)+20.00 \mathrm{~h}=500.00$
D. $15.00(h+3)+20.00 \mathrm{~h}=500.00$
correct answer: A difficult degree: 3
30. A car rental company charges $\$ 34.50$ a day plus a tax of $6 \%$ to rent an economy size car. Additionally, the company charges a one-time untaxed fee of $\$ 10.50$ for each rental. If a customer is charged $\$ 193.98$ in total to rent an economy size car for d days, which of the following equations models the situation?
A. $(34.50+1.06 \mathrm{~d})+10.50=193.98$
B. $1.06(34.50 \mathrm{~d}+10.50)=193.98$
C. $1.06(34.50 \mathrm{~d})+10.50=193.98$
D. $(1.06(34.50)+10.50) d=193.98$
correct answer: C difficult degree: 3
31. Erica has $\$ 50.00$ saved and receives an allowance of $\$ 20.00$ each week. Her older brother, Paolo, has $\$ 20.00$ saved and receives an allowance of $\$ 25.00$ each week.

Which of the following equations best models the number of weeks, $w$, that must pass for the siblings to have the same amount of money saved? Assume that Erica and Paolo save all of their money during this time period.
A. $50.00+20.00 \mathrm{w}=20.00+25.00 \mathrm{w}$
B. $50.00 \mathrm{w}+20.00=20.00 \mathrm{w}+25.00$
C. $20.00(50.00+w)=25.00(20.00+w)$
D. $20.00 \mathrm{w}+25.00 \mathrm{w}=50.00+20.00$ correct answer: A difficult degree: 3
32. The mass of a liquid solution is 25 grams (g) and its volume is 40 milliliters (ml). A second liquid solution has the same density $\left(\frac{g}{m l}\right)$ and a volume of 200 ml . Which of the following equations best models the mass in grams, mm, of the second liquid solution?
A. $200 \mathrm{~m}=(25)(40)$
B. $200 \mathrm{~m}=\frac{25}{40}$
C. $\frac{8}{5}=\frac{m}{200}$
D. $\frac{5}{8}=\frac{m}{200}$
correct answer: D difficult degree: 3
33. Two interior angles of a triangle are complementary. The measure of the first angle is half the measure of the second angle, which has a measure of $x x$ degrees. Which of the following equations best models the sum of the interior angles of this triangle?
A. $x+2 x+90=180$
B. $\frac{x}{2}+x+90=180$
C. $\frac{1}{2}(x+2 x+90)=180$
D. $\frac{x}{2}+\mathrm{x}+2 \mathrm{x}=180$
correct answer: $\mathrm{B} \quad$ difficult degree: 3
34. A park shaped like a pentagon has four equal length sides and one unequal side whose length is 35 feet ( ft ). The perimeter of the park is 195 ft . What is the length in feet of one of the equal sides?
correct answer: 40 difficult degree: 3
35. Sasha has $\$ 2.65$ in change in her pocket. The $\$ 2.65$ is made up of one quarter plus an equal number of nickels and dimes. How many nickels does Sasha have in her pocket?
correct answer: 16 difficult degree: 3
36. The number of subscribers to a certain newspaper decreases by about 2,000 each year. In 2010, there were 19,000 subscribers. In what year should the newspaper expect to have approximately 7,000 subscribers?
correct answer: 2016 difficult degree: 3
37. An airplane begins its descent to land from a height of 35,000 feet ( ft ) above sea level. The airplane's height changes by about -4000 ft every 3 minutes. Rounded to the nearest minute, in approximately how many minutes will the plane land? Assume that the airport runway is at sea level.
correct answer: 26 difficult degree: 3
38. A car driving on a straight path travels about 260 feet ( ft ) in 3 seconds. Rounded to the nearest second, approximately how many seconds will it take for the car to travel 1 mile (mi) at the same rate? $1 \mathrm{mi}=5,280 \mathrm{ft}$.
correct answer: 61 difficult degree: 3
39. As an object's depth below the surface of a body of salt water increases, so does the pressure acting on the object due to atmospheric and water conditions. The rate at which pressure increases is approximately 11 pounds per square inch (psi) for every increase in depth of 25 feet ( ft ). The pressure at the surface of the water is 15 psi. Rounded to the nearest foot, at what depth will the pressure acting on the object be 50 psi?
correct answer: 80 difficult degree: 3
40. A piece of wood has a mass of 30 grams (g) and a volume of 40 cubic centimeters $\left(\mathrm{cm}^{3}\right)$. A second piece of wood has the same density $\left(\frac{g}{\mathrm{~cm}^{3}}\right)$ and a volume of 240
$\mathrm{cm}^{3}$. What is the mass in grams of the second piece of wood?
correct answer: 180 difficult degree: 3
41. A meteorologist estimates that on a sunny day, the air temperature decreases by about $4^{\circ} \mathrm{F}$ for every 1,000 feet ( ft ) of elevation gain. On a certain day, the air temperature outside an airplane flying above Seattle is $-58^{\circ} \mathrm{F}$, and the ground level temperature in Seattle is $70^{\circ} \mathrm{F}$. If x is the height, in feet, at which the plane is flying, which of the following best models the situation?
A. $70=-\frac{4}{1,000} x-58$
B. $70=\frac{4}{1,000} x-58$
C. $-58=-4 x+70$
D. $-58=4 x+70$
correct answer: B difficult degree: 4
42. A taut string of length 10 inches is plucked at the center. The vibration travels along the string at a constant rate of c inches per millisecond in both directions. If $x$ represents the position on the string from the left-most end, so that $0 \leqslant x \leqslant$ 10 , which of the following equations can be used to find the location $x$ of the vibration after 0.3 milliseconds?
A. $\frac{1}{c}|x-5|=0.3$
B. $|c x-5|=0.3$
C. $\frac{1}{c}|x-0.3|=5$
D. $|x-10|=0.3 c$
correct answer: A difficult degree: 4
43. In the year 2006, the average home price per square foot in a certain county was $\$ 98$. For each year before or after 2006, the average price per square foot increased by approximately $\$ 3.50$. In what years could the average home price per square foot be $\$ 119$ ?
A. 2003 and 2009
B. 2002 and 2010
C. 2000 and 2012
D. 1999 and 2013
correct answer: C difficult degree: 4
44. Oliver mows lawns in his neighborhood. He charges $\$ 10$ for each regular yard he mows, and he charges an extra $\$ 5$ for each large yard that he mows. In one week he mowed 6 more large yards than regular yards and made $\$ 265$. If $r$ represents the number of regular yards that Oliver mowed, which equation best models the situation?
A. $10(r+6)+15 r=265$
B. $10(r+6)+5 r=265$
C. $10 r+15(r+6)=265$
D. $10 r+5(r+6)=265$
correct answer: C difficult degree: 4
45. Anna spent 3 hours in her garden planting 6 rosebushes. To plant a rosebush, she first dug the hole, then refilled the hole with the root ball, dirt, and compost. She spent twice as long digging the hole for each plant as she did refilling it. If $m$ represents the minutes spent digging a hole for a single rosebush, which equation best models the situation?
A. $6 m+6(2 m)=3$
B. $6 m+6\left(\frac{m}{2}\right)=3$
C. $6 m+6(2 m)=180$
D. $6 m+6\left(\frac{m}{2}\right)=180$
correct answer: D difficult degree: 4
46. A popular candy is manufactured to weigh 0.16 ounces per piece. The pieces are sold in packages of 36 . If the allowable amount of variation in weight for one piece of candy is 0.03 ounces, which of the following equations can be used to determine the highest and lowest allowable weight, w , of a package of 36 pieces? Assume that the weight of the packaging is negligible.
A. $\frac{|w-0.16|}{36}=0.03$
B. $\frac{|w-5.76|}{36}=0.03$
C. $36|w-0.16|=0.03$
D. $36|w-5.76|=0.03$
correct answer: B difficult degree: 4
12. The maximum activity level of a particular enzyme is 60 micromolars per minute $\left(\frac{\mu \mathrm{M}}{\min }\right)$ and occurs at a temperature of 20 degrees Celsius $\left({ }^{\circ} \mathrm{C}\right)$. For every $2^{\circ} \mathrm{C}$ above or
below $20^{\circ} \mathrm{C}$, the enzyme activity decreases by $8 \frac{\mu \mathrm{M}}{\mathrm{min}}$. Which of the following equations can be used to find the temperatures, T , at which the enzyme activity level is $40 \frac{\mu \mathrm{M}}{\min }$ ?
A. $60-4|T-20|=40$
B. $40+8|\mathrm{~T}-20|=60$
C. $40+4|T-20|=60$
D. $60-8|\mathrm{~T}-20|=40$
correct answer: A difficult degree: 4
47. Uche is a cartographer. He picks a scale to fit a map of India onto a page of an atlas. The page is 12 by 12 inches, with 0.75 inch margins on all 4 sides. India measures 3,214 kilometers from north to south and 2,933 kilometers from west to east. Uche wants the longest dimension of India to fit exactly in between the margins of the page. If $k$ is the number of kilometers per inch in Uche's scale, which equation best models the situation?
A. $\frac{k}{12}=3,214$
B. $12 \mathrm{k}=2,933$
C. $\frac{k}{10.5}=2,933$
D. $10.5 \mathrm{k}=3,214$
correct answer: D difficult degree: 4
48. Alma and Erika work part time stocking shelves at a grocery store. At 7:00 a.m. on Saturday, Alma begins unpacking boxes at a rate of 1 box every 6 minutes. Erika joins her at 7:45 a.m. and unpacks 1 box every 5 minutes. When finished with this task, a total of 24 boxes have been unpacked since 7:00 a.m. If $x$ represents the number of minutes for which Alma has been working, which of the following equations best models the situation?
A. $\frac{1}{6} x+\frac{1}{5}(x-45)=24$
B. $\frac{1}{6} x+\frac{1}{5}\left(x-\frac{3}{4}\right)=24$
C. $6 x+5(x-45)=24$
D. $6 x+5\left(x-\frac{3}{4}\right)=24$
correct answer: A difficult degree: 4
49. On a highway, drivers are required to maintain a speed of between 55 and 65
miles per hour (mph). A $\$ 7$ penalty is assessed for each 1 mph a driver's speed is outside this range. If a driver receives a $\$ 42$ penalty, what are possible values for his speed?
A. 49 and 66 mph
B. 49 and 71 mph
C. 54 and 66 mph
D. 54 and 71 mph correct answer: B difficult degree: 4
50. On January $1^{\text {st }}, 2014$, approximately 450 thousand buildings in the United States (US) had solar panels. This number increased by a total of about 180 thousand over the next 12 months. Assuming a constant rate of change, approximately how many months after January $1^{\text {st }}, 2014$ would 900 thousand buildings in the US have solar panels?
correct answer: 30 difficult degree: 4
51. The gas mileage for a car is 23 miles per gallon when the car travels at 60 miles per hour. The car begins a trip with 13 gallons in its tank, travels at an average speed of 60 miles per hour for $h$ hours, and ends the trip with 10 gallons in its tank. Which of the following equations best models this situation?
A. $13-\frac{23 h}{60}=10$
B. $13-\frac{60 h}{23}=10$
C. $\frac{13-60 \mathrm{~h}}{23}=10$
D. $\frac{13-23 \mathrm{~h}}{60}=10$
correct answer: B difficult degree: 4
52. A kilowatt ( kW ) is equal to 1,000 watts (W), and a kilowatt-hour ( kWh ) is a unit of energy equivalent to one kilowatt of power expended for one hour. For example, an electrical load rated at 1 kW that operates for 1 hour uses 1 kWh of energy. Electricity in a certain city costs $\$ 0.14$ per kilowatt-hour, and a lightbulb rated at 60 W operates in that city for one hour every day for 200 consecutive days. Which equation best models the cost in dollars, c , of the lightbulb over this time period?
A. $c=\frac{60}{1,000} 2000.14$
B. $\mathrm{c}=\frac{1,000}{60} 2000.14$
C. $c=\frac{60}{1,000} \frac{200}{0.14}$
D. $c=60 \square 1,000 \square 200 \square 0.14$ correct answer: A difficult degree: 4
53. Erika's times for the 1-mile run decreased consistently throughout her track season. She estimates that her time for the 1-mile run decreased by about 15 seconds (secs) for every 2 weeks of training. If Erika ran a mile in 8 minutes (mins) and 20 secs at the start of the season, and $x$ weeks into her training ran a mile in 7 mins and 5 secs, which of the following equations best models the situation?
A. $500-7.5 \mathrm{x}=425$
B. $500-15 x=425$
C. $500+7.5 \mathrm{x}=425$
D. $500+15 x=425$
correct answer: A difficult degree: 4

## Linear inequality word problems

1. The following function gives the amount of money owed on a short term loan after t weeks.
$A(t)=100 \cdot 1.25^{\frac{1}{2}}$
Which numerical expression best approximates the annual interest rate, excluding any late fees? ( 1 year=52 weeks.)
A. $1-0.25^{26}$
B. $0.25^{26}-1$
C. $26 \cdot 0.25$
D. $26 \cdot 1.25$

Correct answer: B Difficulty level: 2
2. The rabbit population in an isolated forest rises and falls depending on the population of predators. Within the year 2014, the population, p , in thousands of rabbits mmm months after January 1, 2014 is:
$\mathrm{p}=0.05(\mathrm{~m}-1.5)(\mathrm{m}-8.5)+10$
The population reached ten thousand some time in February. At what other time, given as months after January 1, 2014, did the rabbit population reach ten thousand?

Correct answer: 8.5 Difficulty level: 2
3. The "hang time" of a football is the amount of time the football stays in the air after being kicked. The height, in meters, of the football above the ground at time $t$ can be modeled by the quadratic function:

$$
h(t)=-4.9 t^{2}+19.6 t
$$

Which of the following equivalent expressions displays the hang time of the football as a constant or coefficient?
A. $-4.9(t-2)^{2}+19.6$
B. $-4.9 \mathrm{t}(\mathrm{t}-4)$
C. $-4.9(t-3)^{2}-9.8 t+44.1$
D. $-4.9(t-1)^{2}+9.8 t+4.9$

Correct answer: B Difficulty level: 2
4. Kaia throws a stone vertically upward from a bridge. The height, in meters, of the stone above the water at time $t$ can be modeled by the quadratic function:

$$
h(t)=-4.9 t^{2}+9.8 t+39.2
$$

After how many seconds does the stone hit the water?
A. 1 second
B. 2 seconds
C. 4 seconds
D. 8 seconds

Correct answer: C Difficulty level: 2
5. More than 450 students traveled to a state park for a field trip. The school allowed 6 students to travel by car, and the rest traveled on 11 buses, each of which held the same number of students. If there were s students in each bus, which inequality best represents this situation?
A. $11 \mathrm{~s}+6>450$
B. $11 \mathrm{~s}+6<450$
C. $6 s+11>450$
D. $6 s+11<450$

Correct answer: A Difficulty level: 2
6. A barber charges $\$ 12$ for a haircut. His operating expenses are, on average, $\$ 37$ per day. He calculates his profit by subtracting his operating costs from the money he earns from the haircuts he gives. In a given day, the barber expects to make a profit of at least $\$ 86$. If the barber gives $h$ haircuts in a day, which inequality best models this situation?
A. $12 \mathrm{~h}-37 \geq 86$
B. $12(\mathrm{~h}-37) \geq 86$
C. $12 \mathrm{~h}+37 \geq 86$
D. $12(h+37) \geq 86$

Correct answer: A Difficulty level: 2
7. A distributor ships DVDs to several stores. The shipping boxes contain several DVDs (in their cases) plus a layer of padding at each end of the box. The DVD cases and layers of padding can be arranged neatly inside each box. Each DVD case is 14 mm (millimeters) thick, each layer of padding is 10 mm thick, and the length of the interior of the box is 132 mm . If d represents the number of DVDs that the distributor can fit into one box with two layers of padding, which of the following inequalities best models the situation?
A. $10 d+14 \leq 132$
B. $14 d+20 \leq 132$
C. $20 d+14 \leq 132$
D. $14 d+10 \leq 132$

Correct answer: B Difficulty level: 2
8. To rent a car for one week, a car rental company charges a $\$ 200$ base price as well as $\$ 0.45$ per mile. Jennifer will rent a vehicle at this company, but she has a $\$ 275$ budget. Which of the following is a possible number of miles that Jennifer can drive without exceeding her budget?
A. 166 miles
B. 167 miles
C. 168 miles
D. 169 miles

Correct answer: A Difficulty level: 2
9. Woo-Jin would like to bring several books from his favorite series in his backpack. The backpack can hold up to a depth of $10 \frac{1}{2}$ inches of materials. Woo-Jin's laptop and a notebook fill a total of 3 inches of that depth. Each book would fill 1.5 inches of the depth of the backpack. Only one stack of books can fit the height and width of the backpack. If $x$ represents the number of books that Woo-Jin could carry in his backpack, which of the following inequalities best models the situation described above?
A. $3+1.5 x<10.5$
B. $3+1.5 x \leq 10.5$
C. $3 x+1.5<10.5$
D. $3 x+1.5 \leq 10.5$

Correct answer: B Difficulty level: 2
10. In the year 2000, the average American consumed 8.3 gallons of whole milk per year. This amount has been decreasing by 0.3 gallons per year. Which inequality can be used to find the number of years, $t$, since 2000 when whole milk consumption was greater than 6.0 gallons per person per year?
A. $8.3-0.3 t>6.0$
B. $8.3-0.3(\mathrm{t}-2000)>6.0$
C. $8.3-0.3 t<6.0$
D. $8.3-0.3(\mathrm{t}-2000)<6.0$

Correct answer: A Difficulty level: 3
11. An amusement center charges a $\$ 45$ flat fee for any birthday party plus $\$ 3.50$ for each guest after the first one. Josiah wants to spend no more than $\$ 200$ for his birthday party. If there are x guests, which of the following inequalities best models the situation above?
A. $45+3.50 x \leq 200$
B. $45+3.50(x-1) \leq 200$
C. $45 x+3.50 \leq 200$
D. $45(x-1)+3.50 \leq 200$

Correct answer: B Difficulty level: 3
12. Hamadi is renting a car. With his extreme coupons, the rental charge is $\$ 17.50$ per day plus $\$ 0.16$ per mile. His company will reimburse Hamadi for $\$ 33$ of this portion of the travel expenses. If he rents the car for one day, what is one possible number of miles paid for by the company?
A. 53
B. 97
C. 110
D. 150

Correct answer: A Difficulty level: 3
13. To get to school, Da'Quon walks 0.6 miles from his house to the bus stop. He then takes the bus for 3.9 miles. After he gets off the bus, he can choose one of several walking routes to school. The total amount of miles he travels, via walking and bus, does not exceed 5.4. What is the greatest possible number of miles he walks after getting off the bus?
A. 0.0 miles
B. 0.3 miles
C. 0.9 miles
D. 1.5 miles

Correct answer: C Difficulty level: 3
14. Karim has a $\$ 35$ gift card to his favorite restaurant. Meal tax in his area is $14.3 \%$. Karim would also like to leave a $\$ 5$ tip. If c represents Karim's pre-tax bill, and he wants to pay the entire meal amount, including tip and tax, using the gift card, which of the following inequalities best models the situation described above?
A. $1.143 \mathrm{c}-5 \geq 35$
B. $1.143 c+5 \leq 35$
C. $0.143 c-5 \leq 35$
D. $0.143 c+5 \geq 35$

Correct answer: B Difficulty level: 3
15. One of the rules in a public speaking contest requires contestants to speak for as close to 3 minutes ( 180 seconds) as possible. Contestants lose 2 points for each second they speak either over or under the 3 minutes. If a contestant lost 18 points, what are the possible lengths of time they spoke?
A. 171 and 186 seconds
B. 174 and 186 seconds
C. 171 and 189 seconds
D. 174 and 189 seconds

Correct answer: C Difficulty level: 1
16. A gemologist determines that a gemstone weighs 1.235 carats. Guidelines allow a maximum weighing error of 0.001 carats in reporting gemstone weight. Which of the following equations can be used to determine the smallest and largest possible true weights, c , of the gemstone?
A. $|c-0.001|=1.235$
B. $|c-1.235|=0.1235$
C. $|c-0.001|=0.01$
D. $|c-1.235|=0.001$

Correct answer: D Difficulty level: 1
17. A company's unit cost for producing x units is a minimum when $\mathrm{x}=2,000$ units are produced. The unit cost increases $\$ 0.25$ for every unit more or less than 2,000 produced. Which of the following could be the number of units for which the unit cost increases by $\$ 7.50$ from the minimum?
A. 1,700 or 2,300
B. 1,975 or 2,025
C. 1,997 or 2,003
D. 1,970 or 2,030

Correct answer: D Difficulty level: 1
18. Felipe has a 15 gallon gas tank in his car. He fills his tank, and then drives the x miles back to college. Upon his arrival, he fills his tank for $\$ 20.91$. If his car averages 24 miles per gallon $(\mathrm{mpg})$, and at the time, gas costs $\$ 2.46$ per gallon, which of the following best approximates x ?
A. 128
B. 204
C. 360
D. 502

Correct answer: B Difficulty level: 1
19. In 2005, approximately $16.5 \%$ of seats in national parliaments were held by women. Between 2005 and 2014, this percentage increased at a constant rate of about 3 percentage points every 5 years. If t is the year when approximately $19 \%$ of the seats in national parliaments were held by women, which of the following equations best models the situation?
A. $16.5+3 t=19$
B. $16.5+\frac{3}{5} t=19$
C. $16.5+3(t-2005)=19$
D. $16.5+\frac{3}{5}(t-2005)=19$

Correct answer: D Difficulty level: 1
20. Ella needs a $70 \%$ isopropyl alcohol solution as an antiseptic. She has a 100 milliliter (ml) container of $90 \%$ isopropyl alcohol solution. Approximately how much water should Ella add to dilute it to a $70 \%$ isopropyl alcohol solution? Round to the nearest tenth.
$\qquad$ ml of water
21. For many trees, the approximate age of the tree (in years) is equal to the diameter of the tree (in inches) times the tree's growth factor. Deniz estimates that a certain red maple tree in her yard is about 80 years old. If red maple trees have a growth factor of 4.5 , which of the following equations could be used to find x , the diameter of the tree in feet?
A. $80=12(4.5 x)$
B. $80=\frac{4.5 x}{12}$
C. $80=\frac{12 x}{4.5}$
D. $80=\frac{x}{(12)(4.5)}$

Correct answer: A Difficulty level: 1
22. The property taxes in a town decrease as the distance from the town hall increases. For every 5 miles from the town hall, property taxes decrease by 0.2 percentage points. Which of the following equations can be used to determine how far north or south of the town hall a house is whose property taxes are 0.76 percentage points less than the taxes at the town hall?
Note: y is the position of a house that is directly north or south of the town hall, with $\mathrm{y}>0$ representing north and $\mathrm{y}<0$ representing south.
A. $0.04|y-5|=0.76$
B. $0.04|y|=0.76$
C. $4|y-5|=0.76$
D. $4|y|=0.76$

Correct answer: B Difficulty level: 1
23. Josie's hair currently falls about 16 centimeters ( cm ) below her shoulder and grows about 5 cm every 4 months. Josie plans to grow her hair and donate about 21 cm of her hair to charity after her next haircut. If Josie would like to have her hair fall about 5 cm below her shoulders after her next haircut, which of the following equations could be used to find the number of months, mmm, for which Josie must grow her hair?
A. $1.25 m=5$
B. $1.25 m=21$
C. $16+1.25 m-21=5$
D. $5+1.25 m-16=21$

Correct answer: C Difficulty level: 1
24. Melissa has an 80 inch (in) piece of wrought iron that she wishes to use to make a rectangular piece of art. She wants the length of the rectangular piece of art to be 12 inches longer than
the width. What is the largest length possible?
A. 14 in
B. 26 in
C. 34 in
D. 46 in

Correct answer: B Difficulty level: 1
25. Yong needs to cut a 3 foot long board into several 2 inch lengths. With each cut, his saw blade shaves off an additional $\frac{1}{8}$ inch of the board. What is the maximum number of full 2 inch lengths that Yong can cut from his board?
$\qquad$ lengths

Correct answer: 17 Difficulty level: 1
26. Aria is buying refreshments for a birthday party. She intends to get an ice cream cake for $\$ 23$ and some cupcakes for $\$ 2$ each. Aria has a $\$ 45$ budget but does not have to spend the entire amount. Which inequality best represents the number of cupcakes, c , that Aria can purchase?
A. $\mathrm{c}>11$
B. $\mathrm{c}<11$
C. $\mathrm{c} \geq 11$
D. $\mathrm{c} \leq 11$

Correct answer: D Difficulty level: 2
27. Stan is crocheting scarves to sell at a craft fair. He will give away the first 2 scarves that he crochets and will sell the rest at the craft fair for $\$ 8$ each. His scarves are very popular and people always buy all that he is willing to sell. Stan's goal is to earn at least $\$ 75$ at the craft fair. If n represents the number of scarves which Stan needs to crochet to meet his goal, which of the following inequalities best models the situation described above?
A. $8 n-2 \geq 75$
B. $8 n \geq 75-2$
C. $8(n-2) \geq 75$
D. $(8-2) n \geq 75$

Correct answer: C Difficulty level: 2
28. In golf, someone who completes a course in fewer strokes beats someone who completes it with more strokes. Par means the standard number of strokes it takes to complete a specific course. Amateurs generally require more strokes.

Ayumi averages 1.5 times par strokes per game, but her brother Daiki averages 1.75 times par strokes per game. To make the game more even, Ayumi adds 18 strokes to her total when she plays against Daiki.

Assuming both Ayumi and Daiki play average games, which inequality best represents the par, p , in a golf game where Ayumi beats her brother Daiki?
A. $p>41$
B. $p>54$
C. $p>72$
D. $p>90$

Correct answer: C Difficulty level: 2
29. Arianna and Hannah are conducting an experiment to test the difference threshold for sense of touch on the forehead. For trial 1, Hannah closes her eyes while Arianna gently touches 2 paperclip points 3 millimeters (mm) apart on Hannah's forehead. Then Hannah reports whether she could feel 1 or 2 points. For each of the next trials, Arianna and Hannah repeat this process, each time with the points 2 more mm apart. Hannah reports feeling 1 point until the points are 15 mm apart, when she begins reporting that she feels 2 points. Which inequality best represents the trial numbers in which Hannah feels 2 points?
A. $t>6$
B. $t<6$
C. $t \geq 7$
D. $t \leq 7$

Correct answer: C Difficulty level: 2
30. Turkey's government requires at least a $\frac{2}{3}$ majority of Parliament members to approve any constitutional changes. There are 550 seats in the Parliament. Of those, 313 of the seats are occupied by members who have pledged to support a particular constitutional change. Which inequality represents the number of additional Parliament members, $m$, who would need to support the constitutional change to achieve the required majority?
A. $\mathrm{m} \geq 53 . \overline{6}$
B. $m \geq 158$
C. $m \geq 303$
D. $m \geq 366 . \overline{6}$

Correct answer: A Difficulty level: 2
31. In one state, a minimum of 246,400 valid signatures on a petition is required to get a voter initiative added to a state-wide ballot. The signature collectors can fit 25 signatures per page. They estimate that 61,600 of the signatures that they collect will not be valid (because of being duplicates, incomplete, or unregistered voters). If p represents the number of pages of signatures which the signature collectors should collect in order to get the voter initiative added to the ballot, which of the following inequalities best models the situation described above?
A. $25 p+61,600 \geq 246,400$
B. $25 p+61,600 \leq 246,400$
C. $25 p-61,600 \geq 246,400$
D. $25 p-61,600 \leq 246,400$

Correct answer: C Difficulty level: 2
32. When police analyze the broken glass at a scene, it helps them reconstruct the situation. Headlight glass is much less dense than the window glass. The headlight glass will be 1.5 grams per milliliter or less. A police officer determines that a fragment of glass displaces 10.5 mL of water. Use the formula density $=\frac{\text { mass }}{\text { volume }}$. Which inequality best shows the possible mass, $m$, in grams of the fragment if it is headlight glass?
A. $m \geq 7$
B. $m \leq 7$
C. $m \geq 15.75$
D. $\mathrm{m} \leq 15.75$

Correct answer: D Difficulty level: 2
33. Jennifer wants to spend no more than $\$ 300$ on school clothes. She spends $\$ 75$ on a jacket and wants to buy some shirts that are on sale for $\$ 10$ each. Which inequality represents the number, $s$, of shirts Jennifer can buy?
A. $\mathrm{s}<22$
B. $s>30$
C. $s>37$
D. $\mathrm{s}<38$

Correct answer: A Difficulty level: 3
34. Teddy is delivering boxes of paper to each floor of an office building. Each box weighs 56 pounds, and Teddy himself weighs 140 pounds. If the maximum capacity of an elevator is 2,000 pounds, or one ton, which of the following inequalities describes how many boxes Teddy can safely take on each elevator trip without going over the capacity?
A. $b \geq 32$
B. $\mathrm{b} \leq 32$
C. $b \geq 33$
D. $\mathrm{b} \leq 33$

Correct answer: D Difficulty level: 3
35. A small airplane can carry less than 1050 pounds of luggage and mail. Tuesday's load of mail weighs 490 pounds. If each passenger brings 70 pounds of luggage, what is the greatest possible number of passengers that can travel on the airplane on Tuesday?
A. 7
B. 8
C. 14
D. 15

Correct answer: A Difficulty level: 3
36. Trevon is going to buy a coat and a hat. The coat costs 3 times as much as the hat. He must spend less than $\$ 94$. If the cost of the hat costs x dollars, which inequality best models this situation?
A. $3 x<94$
B. $3 x>94$
C. $4 x<94$
D. $4 x>94$

Correct answer: C Difficulty level: 3
37. A shipping company charges $\$ 3.46$ for the first pound of a package and $\$ 1.53$ for each additional pound of the package. If Robin wants to spend under $\$ 100$ on shipping, which inequality best represents how many pounds, p , Robin can have in her particular package?
A. $3.46+1.53 p<100$
B. $3.46+1.53(p-1)<100$
C. $3.46+1.53 p-1<100$
D. $3.46(p-1)+1.53<100$

Correct answer: B Difficulty level: 3
38. Members of the wrestling team are planning to sell pre-ordered programs at matches. The cost to print the programs is $\$ 150$ plus $\$ 0.50$ per program. They plan to sell each program for $\$ 2$. If profit is the amount of money earned from selling programs minus the expenses of printing the programs, how many programs must they sell to make a profit of at least $\$ 500$ ?
A. 260
B. 261
C. 433
D. 434

Correct answer: D Difficulty level: 4
39. Christopher has at most $\$ 18.50$ to spend at a convenience store. He buys one bag of bananas for $\$ 1.50$ and a bottle of apple juice for $\$ 1.55$. If gasoline at this store costs $\$ 2.35$ per gallon, which of the following number of gallons can he buy for his car without exceeding his budget?
A. 4.23
B. 7.61
C. 10.82
D. 15.17

Correct answer: A Difficulty level: 4
40. Jonas is traveling by bus to visit a friend who lives 300 miles away. The friend has asked Jonas to call at least 30 minutes before arriving, so he can pick up Jonas. Jonas's bus travels at a constant speed of 45 miles per hour. Which inequality shows the number of travel hours, $t$, before which Jonas should call his friend?
A. $\mathrm{t} \leq 6 \frac{1}{6}$
B. $\mathrm{t} \geq 6 \frac{1}{6}$
C. $\mathrm{t} \leq 6 \frac{2}{3}$
D. $\mathrm{t} \geq 6 \frac{2}{3}$

Correct answer: A Difficulty level: 4
41. One particular hotel in the downtown area costs $\$ 90$ a night. An additional $10 \%$ tax is added to the original cost of the hotel room. There is also a one-time $\$ 12$ parking charge, and a family can expect to spend $\$ 30$ on tips during their stay. How many nights can a family spend at the hotel without exceeding their budget of $\$ 600$ ?
A. 5
B. 6
C. 62
D. 66

Correct answer: A Difficulty level: 4
42. An audiologist is testing a patient to determine the softest sound of a specific frequency that the patient reports hearing. She begins with a 10 decibel $(\mathrm{dB})$ sound for trial 1 , then increases the volume by 2 dB for each trial after that. If the patient can hear all sounds of that frequency that have a volume louder than 26 dB , and t represents the trial numbers that the patient can hear, which of the following inequalities best models the situation described above?
A. $2 t+10 \geq 26$
B. $2 t+10>26$
C. $2(\mathrm{t}-1)+10 \geq 26$
D. $2(t-1)+10>26$

Correct answer: D Difficulty level: 4
43. A college student has equally weighted exam grades of 71,83 , and 90 on three 100 -point exams. The student has one more 100-point exam that counts toward his grade and wants an
exam average of at least 84 . Which inequality represents the range of scores the student can get to achieve this desired exam average?
A. $m \geq 8$
B. $\mathrm{m} \geq 79$
C. $m \geq 81$
D. $\mathrm{m} \geq 92$

Correct answer: D Difficulty level: 3
44. Crys began a workout regimen at a local health club. She began her workouts at 45 minutes each, but has since increased the workouts by 5 minutes per week. Her total workout time cannot exceed 2 hours. If Crys has workouts for x weeks until she hits 2 hours, which inequality best models the situation?
A. $45 x+5 \leq 120$
B. $45 x+5 \geq 120$
C. $45+5(x-1) \leq 120$
D. $45+5 x \leq 120$

Correct answer: C Difficulty level: 3
45. Anais donates blood for the first time on May $15^{\text {th }}$, the $135^{\text {th }}$ day of the year. She may donate again every 56 days. If n is the number of total times which Anais donates this year, which equation best models the situation for $\mathrm{n} \geq 1$ ?
A. $56 n+135 \leq 365$
B. $56(n-1)+135 \leq 365$
C. $56 n-1+135<365$
D. $56(\mathrm{n}+135)<365$

Correct answer: B Difficulty level: 3
46. Joanne and Richard volunteer at a hospital. Joanne volunteers 4 hours more per week than Richard does. In a given week, they do not volunteer for more than a combined total of 16 hours. If $x$ is the number of hours that Richard volunteers, which inequality best models this situation?
A. $x+4 \leq 16$
B. $2 x+4 \leq 16$
C. $2 x+8 \leq 16$
D. $2 x-4 \leq 16$

Correct answer: B Difficulty level: 4
47. Mikal has a summer project in which he must complete at least 35 hours of community service at a city park. Each day that he goes to the park, he volunteers for 7 hours. It takes him 1.5 hours to get to the park each way, which also counts toward his community service hours.

Which of the following inequalities can be used to find the number of days, d , Mikal must volunteer at the park to complete his summer project?
A. $7 \mathrm{~d}>35$
B. $7 \mathrm{~d} \geq 35$
C. $7 \mathrm{~d}+3>35$
D. $7 d+3 d \geq 35$

Correct answer: D Difficulty level: 4
48. An insurance agent sells an insurance policy with an out-of-pocket maximum of $\$ 5,000$. Out-of-pocket expenses include any deductibles and coinsurance that the client pays beyond the normal monthly premium. The client has a deductible of $\$ 250$. This means that the client has to pay all of the first $\$ 250$ of expenses insured by the policy. After that, the client has a $20 \%$ co-insurance, meaning the client pays $20 \%$ of the insured expenses and the insurance company pays the remainder. Which inequality represents how much the total insured expenses, x , could be if the client has not yet reached the out-of-pocket maximum?
A. $x<26,000$
B. $x<25,000$
C. $x<24,000$
D. $x<23,750$

Correct answer: C Difficulty level: 4

## Graphing linear equations

1. The average price of a certain type of coffee worldwide was $\$ 0.51$ per pound in 2008. The price per pound increased about $\$ 0.18$ each year until 2014, and is expected to do so for the next two years. Which of the following graphs represents the relationship between years after 2008, $t$, and price per pound, $P$, in dollars, of this coffee worldwide?





Correct Answer: A Difficult level: 3
2. A farmer observes that the demand for corn Q , in thousands of bushels per month, and price P , in dollars per bushel, are related by a linear function. If a demand of 2,500 bushels per month corresponds to a price of $\$ 4.00$ per bushel, and a demand of 3,000 bushels per month corresponds to a price of $\$ 3.20$ per bushel, which of the following graphs represents the relationship between P and Q ?


Correct Answer: D Difficult level: 3
3. The lines $f$ and $g$ are graphed BELOW in the xy-plane. Line $g$ can be written as the equation $y=a x+b$, where $a$ and $b$ are constants. Which of the following equations represents line $f$ ? Please choose from one of the following options.

A. $y=a x-b$
B. $y=-a x+b$
C. $-y=a x+b$
D. $x=a y+b$

Correct Answer: C Difficult level: 3
4. Which of the following graphs represents the equation $(y+6)=-\frac{3}{2} \quad(x-8)$
A.

B.

C.


D.

Correct Answer: A Difficult level: 3
5. The equation $6 y+12 x=18$ is graphed in the $x y$-plane. Which of the following equations has a graph that is perpendicular to the graph of the above equation?
A. $y=-2 x+3$
B. $y=\frac{1}{2} x+3$
C. $y=2 x+3$
D. $y=-\frac{1}{2} x+3$

Correct Answer: B Difficult level: 3
6. Which of the following equations represents a line in the xy-plane with an $x$-intercept at $(-2,0)$ and a slope of 4 ?
A. $y=4 x+8$
B. $y=-4 x+8$
C. $y=4 x-2$
D. $y=-4 x-2$

Correct Answer: A Difficult level: 2
7. The equation $y=\frac{3}{2}(x-8)$ is graphed in the xy-plane. Which of the following equations will have a graph that is parallel to the graph of the above equation and have an $x$-intercept on the negative x -axis?
A. $y=\frac{3}{2}(x+8)$
B. $y=\frac{3}{2} x-8$
C. $y=-\frac{2}{3}(x+8)$
D. $y=-\frac{2}{3} x-8$

Correct Answer: A Difficult level: 2
8. The equation $\mathrm{y}=\mathrm{x}+\mathrm{a}$ is graphed in the xy -plane, where a is a positive constant. A second equation, $y=x-a$, is graphed in the same $x y-p l a n e . ~ H o w ~ d o ~ t h e ~ s l o p e ~ a n d ~$ $y$-intercept of the graph of the first equation compare with the slope and $y$-intercept of the graph of the second equation?
A. The slopes are the same; the y-intercept of the first equation's graph is the point ( 0 ,
a), and the $y$-intercept of the second equation's graph is the point $(0,-a)$.
B. The slopes are the same; the $y$-intercept of the first equation's graph is the point $(0,-a)$, and the $y$-intercept of the second equation's graph is the point $(0, a)$.
C. The $y$-intercepts are the same; the slope of the first equation's graph is a, and the slope of the second equation's graph is -a.
D. The $y$-intercepts are the same; the slope of the first equation's graph is -a , and the slope of the second equation's graph is a.
Correct Answer: A Difficult level: 2
9. Which of the following is an equation of the line A graphed in the xy-plane that passes through the point $(-1,3.5)$ and is perpendicular to the line B whose equation is $\mathrm{x}+4.5=0$ ?
A. $x=-1$
B. $x=3.5$
C. $y=3.5$
D. $y=4.5$

Correct Answer: C Difficult level: 2
10. A line is graphed as shown BELOW. Which of the following equations represents the line?

A. $y=\frac{2}{5} x+2$
B. $y=\frac{2}{5} x-2$
C. $\mathrm{y}=-\frac{2}{5} \mathrm{x}+2$
D. $y=-\frac{2}{5} x-2$

Correct Answer: D Difficult level: 2
11. Which of the following equations represents the line graphed BELOW in the xy-plane?

A. $x=-4$
B. $y=-4$
C. $y=x-4$
D. $x=y-4$

Correct Answer: B Difficult level: 2
12. Which of the following equations represents a line in the xy-plane with an $x$-intercept at $(-2,0)$ and a slope of 4 ?
A. $y=4 x+8$
B. $y=-4 x+8$
C. $y=4 x-2$
D. $y=-4-2$

Correct Answer: A Difficult level: 2
13. Which of the following equations represents a line in the xy-plane with an $x$-intercept at $(-15,0)$ and a $y$-intercept at $(0,-9)$ ?
A. $\frac{x}{15}+\frac{y}{9}=1$
B. $-\frac{x}{15}-\frac{y}{9}=1$
C. $\frac{x}{9}-\frac{y}{15}=1$
D. $-\frac{x}{9}+\frac{y}{15}=1$

Correct Answer: B Difficult level: 3
14. Two lines graphed in the $x y$-plane have the equations $2 x+5 y=20$ and $y=k x-3$, where k is a constant. For what value of k will the two lines be perpendicular?
A. $-\frac{2}{5}$
B. $\frac{2}{5}$
C. $\frac{5}{2}$
D. $-\frac{5}{2}$

Correct Answer: C Difficult level: 3
15. A rectangle is said to have a golden ratio if the ratio of its length to width is equal to approximately 1.6 . Which of the following graphs represents the relationship between length, 1 , and width, w , in a golden rectangle?


Correct Answer: A Difficult level: 3
16. The line graphed BELOW in the xy-plane can be written as the equation $\mathrm{y}-\mathrm{c}=$ $\mathrm{m}(\mathrm{x}-\mathrm{d})$, where $\mathrm{c}, \mathrm{d}$, and m are constants. Which of the following represents the graph of $\mathrm{y}-\mathrm{c}+4=\mathrm{m}(\mathrm{x}-\mathrm{d}-4)$ ?


Correct Answer: A Difficult level: 3
17. Which of the following represents the graph of the equation $3 y-7=0$ ?
A.


B.

C.

D.
Correct Answer: C Difficult level: 4
18. The equations $x+y=3$ and $-5 x-5 y=-15$ are graphed in the $x y-p l a n e$. Which of the following must be true of the graphs of the two equations?
A. The slope of the graph of $x+y=3$ is 11 and the slope of the graph of $-5 x-5 y=-15$ is -1 .
B. The graphs of the two equations are perpendicular lines.
C. The yy-intercept of the graph of $-5 x-5 y=-15-5 x-5 y=-15$ is $-15-15$.
D. The graphs of the two equations are the same line.

Correct Answer: D Difficult level: 4
19. Which of the following represents the graph of the equation $\mathrm{x}=-\frac{1}{3} y$
A.


B.
C.

D.

Correct
Answer: D Difficult level: 4
20. The line represented by the equation $\mathrm{y}=\frac{1}{12}-x$ is graphed in the xy -plane. Which of the following statements correctly describes the graph of the line?
A. The line is perpendicular to the graph $\mathrm{x}+\mathrm{y}=1$.
B. The line has a negative slope and a positive $y$-intercept.
C. The line has a positive slope and a negative $y$-intercept.
D. The $x$-intercept is equal to the negative of the $y$-intercept.

Correct Answer: B Difficult level: 4
21. If k is a rational constant not equal to 1 , which of the following graphs represents the equation $\mathrm{y}+5=\mathrm{k}(\mathrm{x}+\mathrm{y})+5$ ?


A.
B.


Correct Answer: A Difficult level: 4
22. What is the equation of the line graphed in the xy-plane that passes through the point $(-4,-5)$ and is parallel to the line whose equation is $3 x-4 y=-8$ ?
A. $\mathrm{y}=-\frac{4}{3} x+10$
B. $y=\frac{3}{4} x-2$
C. $y=\frac{3}{4} x-8$
D. $\mathrm{y}=-\frac{4}{3} x-8$

Correct Answer: B Difficult level: 4
23. The equations below are graphed in the xy-plane. Which equation's graph will have a slope of $\frac{7}{8}$ and a $y$-intercept of 3 ?
A. $7 x+8 y=24$
B. $7 x-8 y=-24$
C. $8 x+7 y=3$
D. $7 x-8 y=3$

Correct Answer: B Difficult level: 4
24. The equation for the gravitational potential energy $U$ of a 1-kilogram object on Earth resting $h$ meters above the ground $t$ seconds after placement is $U=9.8$ h joules. Which of the following is a graph of $U$ versus $t$ for a 1-kilogram object 2 meters above the ground?


## Linear function word problems

## LEVEL 2

1. Vendors at a craft fair pay $\$ 45$ to rent a table for the day. Benjamin rents a table at the craft fair and sells 8 ounce jars of jam for $\$ 7.95$ per jar. If it costs Benjamin \$2.75 to make each container of jam, which of the following equations best models his profit, $p$, from one day at the craft fair if he sells $n$ jars of jam?
A. $p=5.20 n$
B. $p=7.95 n$
C. $p=5.20 n-45$
D. $p=7.95 n-45$

Correct answer: C
2. John manufactures household furniture. His start-up costs, including tools, plans, and advertising, total $\$ 5000$. Labor and materials for each piece of furniture total $\$ 350$, and his production costs are the sum of his start-up costs plus the cost of labor and materials. If John makes $f$ pieces of furniture, what will be his production costs, $c$, in dollars?
A. $f=350 c+5000$
B. $c=350 f+5000$
C. $f=5000 c+350$
D. $c=5000 f+350$

Correct answer: B
3. The number of problems assigned as homework by a savvy math professor is a function of the length of the class on a particular day, which is either 45 minutes, 90 minutes, or 135 minutes. He first multiplies the number of minutes by 4 and then divides that number by 9 . Finally, he subtracts 12 from that amount. Which
of the following functions best represents the number of math problems the professor assigns depending on the length of the class, $t$, in minutes?
A. $f(t)=94 t-12$
B. $f(t)=94(t-12)$
C. $f(t)=12-94 t$
D. $f(t)=12+94 t$

Correct answer: A
4. Imani's grandmother's house is 5 miles west of her own house down Main Street. While at her grandmother's, Imani decides to ride her bike farther west down Main Street at 10 miles per hour. Which equation best describes the distance, $d$, in miles, Imani is from home after $t$ hours?
A. $d=5+10 t$
B. $d=5-10 t$
C. $d=5 t+10$
D. $d=5 t-10$

Correct answer: A
5. Hiroto spends $\$ 68$ on e-books and paperback books combined. Each e-book he buys costs $\$ 5$, and each paperback book he buys costs $\$ 12$. If Hiroto buys $x$ e-books and $y$ paperback books, which of the following equations best models the situation?
A. $5 x+12 y=68$
B. $12 x+5 y=68$
C. $17(x+y)=68$
D. $17 x y=68$

Correct answer: A
6. A construction company's fees include a flat daily charge to come to a work site, in addition to a constant hourly rate. Any fractional hours are charged at that fraction of the hourly rate. Additionally, if a job takes less than 10 hours to complete, it is completed in one day. According to these rules, a 3.5 hour job would cost $\$ 250$ and an 8 hour job would cost $\$ 475$. If the construction company completes a job in one day, which of the following functions best models the cost, $c$, in dollars, for an $h$ hour job?
A. $c(h)=50 h$
B. $c(h)=60 h$
C. $c(h)=50 h+75$
D. $c(h)=60 h+10$

Correct answer: C
7. From 2005 to 2013, the population of Belize has been increasing by approximately 7,500 people per year. The population of Belize in 2010 was 308,595. If $t$ stands for years since 2005, which of the following functions best models the population, $p$, of Belize during this time period?
A. $p(t)=271,095+7,500 t$
B. $p(t)=308,595+7,500 t$
C. $p(t)=346,095+7,500 t$
D. $p(t)=-14,728,905+7,500 t$

Correct answer: A
8. In a political science class, test scores were determined to be 20 times the number of hours, $h$, the student studied plus 3 . Which of the following functions best describes a student's test score depending on the number of hours, $h$, that the student studied?
A. $f(h)=3 h+20$
B. $f(h)=20 h$
C. $f(h)=60 h$
D. $f(h)=20 h+3$

Correct answer: D
9. A 300 -room hotel collects $\$ 75$ per occupied room and does not collect any money for vacant rooms. Which of the following functions best represents how many dollars, $d$, the hotel generates given the number of vacant rooms in the hotel, $v$ ?
A. $d=75(300-v)$
B. $d=75(300+v)$
C. $d=300(75-v)$
D. $d=300(75+v)$

Correct answer: A

## LEVEL 3

1. Dalia makes a cranberry apple punch that contains $20 \%$ real juice by mixing $x$ gallons of a cranberry drink with $y$ gallons of an apple drink. The cranberry drink contains $40 \%$ real juice and the apple drink contains $10 \%$ real juice. Which of the following equations represents the relationship between $x$ and $y$ ?
A. $0.4 x+0.1 y=20$
B. $0.4 x+0.1 y=x+y$
C. $0.20(x+y)=x+y$
D. $0.2(x+y)=0.4 x+0.1 y$

Correct answer: D
2. Gary learned that the value of his car depreciates by $15 \%$ per year. Which of the following functions best describes the value of his car the year after the car is worth $m$ dollars?
A. $f(m)=0.15 m$
B. $f(m)=0.85 m$
C. $f(m)=1-0.15 m$
D. $f(m)=1-0.85 m$

Correct answer: B
3. Javier has a cell phone plan that allows him to use up to 4 gigabyte (GB) of data per month. Streaming videos is the only action he does on his phone which uses
up this data. Each time he streams a video, the amount of gigabytes of his phone's data plan decreases. Specifically, his cell phone company estimates that approximately 0.12 GB of data are used for every 30 minutes of video streaming. If Javier has spent $m$ minutes this month streaming videos, which of the following best approximates the amount of data, $d$, he has remaining on his plan?
A. $d=4-0.12 m$
B. $d=4+0.12 m$
C. $d=4-0.004 m$
D. $d=4+0.004 m$

Correct answer: C
4. Li Jing has already read $\frac{1}{3}$ of her 384 page book. She figures that she reads at a constant rate and can read about 45 pages in 11 hour. If $\mathrm{m} m$ is the amount of time, in minutes, that Li Jing has spent reading the final $\frac{2}{3}$ of the book, which of the following best approximates the number of pages, $p$, that she has left?
A. $p=128-45 m$
B. $p=256-45 m$
C. $p=128-43 m$
D. $p=256-43 m$

Correct answer: D
5. Between 2008 and 2012, the revenue obtained from digital music album downloads, $r$, in millions of dollars, in the United States increased by approximately 132 million dollars per year. In 2010, the digital music revenue in
the U.S. was about 872 million dollars. If $t$ represents years since 2008, which of the following best models the situation for $0 \leq t \leq 4$ ?
A. $r(t)=132 t$
B. $r(t)=132 t+608$
C. $r(t)=132 t+872$
D. $r(t)=132 t+1136$

Correct answer: B
6. David's vehicle has a 21 gallon gas tank. If he drives only on highways, he can go about 525 miles on one tank of gas. If he drives only in the city, he can go about 378 miles on one tank of gas. David drove 455 miles on his last tank of gas. If $x$ is the amount of gallons used on highway driving and $y$ is the gallons used on city driving, which of the following best models the relationship between $x$ and $y$ in this situation?
A. $25 x+18 y=21$
B. $25 x+18 y=455$
C. $525 x+378 y=21$
D. $525 x+378 y=455$

Correct answer: B
7. Mikayla is a waitress who makes a guaranteed $\$ 50$ per day in addition to tips of $20 \%$ of all her customer receipts, $t$. She works six days per week. Which of the following functions best represents the amount of money that Mikayla makes in one week?
A. $f(t)=50+20 t$
B. $f(t)=300+20 t$
C. $f(t)=50+0.2 t$
D. $f(t)=300+0.2 t$

Correct answer: D
8. John's seafood restaurant is trying to estimate its profits. John has found that on average, each meal served costs the restaurant $\$ 14.56$ and takes in $\$ 17.12$. John has also found that on average, each beverage served costs the restaurant $\$ 1.20$ and takes in $\$ 5.40$. If $c$ customers order a meal, and half of those customers order a beverage, which of the following functions models the restaurant's total profit?
A. $f(c)=17.12 c-14.56 c+5.40\left(\frac{1}{2} c\right)^{-1.20\left(\frac{1}{2} c\right)}$
B. $f(c)=17.12 c-14.56 c+5.40 c-1.20 c$
C. $f(c)=14.56 c-17.12 c+1.20 c-5.40 c$
D. $f(c)=14.56 c-17.12 c+1.20\left(\frac{1}{2} c\right)-5.40\left(\frac{1}{2} c\right)$

Correct answer: A

## LEVEL 4

1. Maria burns about 600 calories per hour jogging and about 450 calories per hour biking. If Maria spends $x$ hours per day biking, and $\frac{4}{5}$ as much time jogging, which of the following functions best models the amount of calories, $C$, that Maria burns in one day from jogging and biking?
A. $C(x)=840 x$
B. $C(x)=930 x$
C. $C(x)=960 x$
D. $C(x)=1050 x$

Correct answer: B
2. Mikayla walked nine miles in three hours. She walked $f$ miles during the first hour and $\frac{2}{3}$ of the remaining distance during the second hour. Which of the following functions best represents the number of miles in the third hour, $t$, she had to walk in terms of the number of miles she walked in the first hour, $f$ ?
A. $t=3$
B. $t=3-\frac{1}{3} f$
C. $t=3+\frac{2}{3} f$
D. $t=3+f$

Correct answer: B
3. The gas tank in Ms. Brown's car holds a total of 15 gallons. At any given time, how many gallons, $g$, will Ms. Brown have to pump into her car to fill her tank given the fraction of the tank, $f$, already filled?
A. $g=15 f$
B. $g=\frac{15}{f}$
C. $g=15-15 f$
D. $g=15-\frac{15}{f}$

Correct answer: C
4. Sterling silver is an alloy of silver that is $92.5 \%$ pure silver. If $x$ grams of sterling silver are mixed with $y$ grams of an $88 \%$ silver alloy to produce a $91 \%$ silver alloy, which of the following equations correctly relates $x$ and $y$ ?
A. $0.075 x+.12 y=0$
B. $0.015 x-0.03 y=0$
C. $0.925 x+0.88 y=91$
D. $0.925 x+0.88 y=0.91 x y$

Correct answer: B
5. A roller coaster is currently traveling at a speed of 49 miles per hour ( mph ). The coaster's speed will increase at a constant rate of 17 mph every 2 seconds until the coaster reaches its top speed 5 seconds from now. If $t \leq 5$, which function best represents the roller coaster's speed, in miles per hour, $t$ seconds from now?
A. $f(t)=49+8.5 t$
B. $f(t)=49+17 t$
C. $f(t)=49 t+9.8 t$
D. $f(t)=49 t+17 t$

Correct answer: A
6. Gustav is starting a special sprinting regimen in outdoor track. The regimen suggests sprinting for a certain number of seconds, $s$, at first. The second time he sprints, he should run 150 more seconds than the first time. For the third time, the regimen suggests sprinting twice the number of seconds as the first time. Finally, the regimen suggests an 80 -second sprint. Which of the following functions can be used to find the total number of seconds, $t$, suggested by the entire sprinting regimen?
A. $t=s+230$
B. $t=2 s+230$
C. $t=\frac{5}{2} s+230$
D. $t=4 s+230$

Correct answer: D
7. In 2007, approximately $50 \%$ of the world's population lived in rural (defined as non-urban) areas. From 2005 to 2013, the percent of the world's population living in rural areas decreased by about 0.5 percentage points per year. If $t$ represents years since 2005, which of the following equations best models the percent of the world's population living in rural areas, $r$, from 2005 to 2013?
A. $r-50=-0.5(t-2)$
B. $r-50=-0.5(t-7)$
C. $r-2=-0.5(t-50)$
D. $r-7=-0.5(t-50)$

Correct answer: A
8. Maria burns about 600 calories per hour jogging and about 450 calories per hour biking. If Maria spends $x$ hours per day biking, and $\frac{4}{5}$ as much time jogging, which of the following functions best models the amount of calories, $C$, that Maria burns in one day from jogging and biking?
A. $C(x)=840 x$
B. $C(x)=930 x$
C. $C(x)=960 x$
D. $C(x)=1050 x$

Correct answer: B

## Part VII Systems of linear inequalities word problems

1. Anouk is an engineer planning sound and lighting for a free concert in the park. The concert was advertised with a promise to use no more than 108 kilowatts ( kW ) of power. It was determined that the main contributors to power usage, speakers and floodlights, use 1.8 kW and 2.2 kW , respectively. Anouk also must keep within her budget of $\$ 3,300$. The rental company is charging $\$ 75$ for each speaker and $\$ 42$ for each floodlight. Which of the following combinations meets Anouk's requirements?
A. 40 speakers and 30 floodlights
B. 12 speakers and 54 floodlights
C. 26 speakers and 13 floodlights
D. 38 speakers and 22 floodlights

CORRECT ANSWER: C
DIFFICULTY LEVEL: 2
2. In order to keep a malfunctioning satellite from falling into the earth, space agency officials decide to use a powerful rocket. At the time the rocket is attached, the satellite will be traveling with an initial velocity, $v_{0}$, and for every second that the rocket fires, it will add approximately 180 meters per second, $\left(\frac{m}{s}\right)$ to this velocity. In order to ensure safety on earth, the velocity must be increased to at least 3,800 $\frac{\mathrm{m}}{\mathrm{s}}$. Also, the rocket can fire for no more than 4 seconds. For the initial velocity of the satellite, $v_{0}$, which of the following systems of inequalities best models this situation, where $t$ is time, in seconds, after the rocket is first fired?
A. $v_{0}+180 \mathrm{t} \geqslant 3,800, \quad \mathrm{t} \leqslant 4$
B. $v_{0}+180 \mathrm{t} \geqslant 3,800, \quad 180 \mathrm{t} \leqslant 4$
C. $v_{0}+3,800 \leqslant 180 \mathrm{t}, \mathrm{t} \leqslant 4$
D. $v_{0}+3,800 \leqslant 180 t, \quad 180 t \leqslant 4$

CORRECT ANSWER: A DIFFICULTY LEVEL: 2
3. Vijay needs to take a taxi, which costs a flat fee of 3 dollars, plus an additional 4 dollars per mile. If Vijay has $a$ dollars with him, which inequality shows the number of miles, $m$, he can afford to travel in the taxi?
A. $0 \leqslant m \leqslant 4 a \quad 3$
B. $0 \leq m \leq \frac{a}{4}-\frac{3}{4}$
C. $4 \mathrm{a}-3 \leqslant \mathrm{~m}$
D.

CORRECT ANSWER : B
DIFFICULTY LEVEL : 2
4. The change machine at an arcade gives change in the form of 25 -cent coins (quarters) and one-dollar bills. The manager of the arcade would like at least $\$ 50$ worth of quarters and $\$ 100$ worth of one-dollar bills in the machine at all times. Also, the manager does not allow more than $\$ 500$ in the machine at any time. What is the maximum number of quarters the manager would allow in the change machine?
A. 200
B. 400
C. 1600
D. 2000

CORRECT ANSWER: C DIFFICULTY LEVEL: 2
5. In order to bring his business to the next level, Christov wants to gain at least 2,000 followers on a popular social media platform. From his own personal account, he knows that each original post gains him approximately 3 new followers and every 5 reposts gains about 1 . Which of the following inequalities represents the numbers of
posts, P , and reposts, R , Christov needs to reach his goal of gaining 2,000 followers?
A. $3 \mathrm{P}+0.2 \mathrm{R} \geqslant 2,000$
B. $3 \mathrm{P}+5 \mathrm{R} \leqslant 2,000$
C. $1 P+5 R \geqslant 2,000$
D. $0.2 \mathrm{P}+5 \mathrm{R} \leqslant 2,000$

## CORRECT ANSWER: A DIFFICULTY LEVEL: 2

6. A company sells candy in jars that each have a volume of $\mathbf{3}$ cups. Each jar is filled above a certain line, guaranteeing that it has more than $\frac{8}{3}$ cups of candy. Which of the following graphs shows the possible volumes of candy, $\mathcal{C}$, in cups, a customer may have, given that they bought $j$ jars of candy?
A.

B.

C.

D.


## CORRECT ANSWER: B DIFFICULTY LEVEL: 3

7. In a baseball game, a player must touch $\mathbf{4}$ bases to get a run. However, some players get "out" before reaching the $4^{\text {th }}$ base, in which case the bases don't contribute towards a run. Let $b$ be the total number of bases a player touches in one game and $r$ be the total number of runs he gets from those bases. Which of the following graphs shows the possible number of bases a player touches, given the number of runs he gets?
A.

B.

C.

D.

8. Prachi needs between 240 and 260 total feet of fence panels. The home improvement store has 24 short (6-foot) fence panels and 28 long ( 8 -foot) fence panels in stock. Which of the following combinations of fence panels could she buy?
A. 6 short fence panels and 26 long fence panels
B. 8 short fence panels and 23 long fence panels
C. 27 short fence panels and 12 long fence panels
D. 30 short fence panels and 10 long fence panels

## CORRECT ANSWER: A DIFFICULTY LEVEL: 3

9. Li Qiang is listening to a symphony that has 2 movements. The first movement has 3 beats per measure and the second movement has 4 beats per measure. The symphony has 446 measures. In an attempt to count the beats, Li Qiang counts at least $x$ of the beats in the first movement and exactly $b$ beats in the second movement. Let $x$ be the number of beats in the first movement and $b$ be the number of beats in the second movement. Which of the following inequalities must be true?
A. $\frac{x}{3}+\frac{b}{4} \leq 446$
B. $\frac{x}{3}+\frac{b}{4} \geq 446$
C. $3 x+4 b \leq 446$
D. $3 x+4 b \geq 446$

## CORRECT ANSWER: A

DIFFICULTY LEVEL: 3
10. Priyanka's car gets a maximum of 35 miles per gallon. According to a particular convention, the "wear" on a vehicle is at least $\frac{15}{4}$ times the total number of miles driven plus the total number of gallons used. For Priyanka's car, let $m$ be the total
number of miles driven, let $g$ be the total number of gallons used, and let $w$ be the "wear". Which of the following systems of inequalities correctly represents these relationships?
A. $w-g \geq \frac{15}{4} m$
$m \leq 35 g$
B. $w-g<\frac{15}{4} m$
$m \geq 35 g$
C. $w-g \geq \frac{15}{4} m$
$35 m \leq g$
D. $w-g<\frac{15}{4} m$
$35 m \geq g$
CORRECT ANSWER: A DIFFICULTY LEVEL: 3
11. $K=\left(4.14 \cdot 10^{-15}\right) v-\phi$

In night vision goggles, light rays cause electrons to be projected from a metal surface. The above equation relates the kinetic energy in electron volts (e $V$ ), $K$, of emitted electrons to the frequency in hertz, $v$, of incident light rays and the work function, $\phi$, in $\mathrm{e} V$, of the metallic surface.

In a particular set of night vision goggles, the electrons emitted must have a kinetic energy of at least $2.46 \mathrm{e} V$. If the frequency of incoming light rays is less than $9.60 \cdot 10^{14}$ hertz, which of the following systems of inequalities best models the relationship between the work function, $\phi$, and the light source frequency, $v ?$
A.
$v>9.60 \cdot 10^{14}$
$\phi \leq\left(4.14 \cdot 10^{-15}\right) v-2.46$
B. $v<9.60 \cdot 10^{14}$
$\phi \leq\left(4.14 \cdot 10^{-15}\right) v-2.46$
C. $v>9.60 \cdot 10^{14}$
$\phi \geq\left(4.14 \cdot 10^{-15}\right) v+2.46$
D. $v<9.60 \cdot 10^{14}$
$\phi \leq\left(4.14 \cdot 10^{-15}\right) v+2.46$

## CORRECT ANSWER: B DIFFICULTY LEVEL: 2

12. Paper Scraper, Inc, a mobile paper shredding and recycling company, receives $\$ 0.39$ for each pound of paper they shred, but it costs them approximately $\$ 1.38$ per mile to operate their truck. Any job that requires less than 200 miles of travel, and also nets at least $\$ 500$ profit, qualifies for free delivery. Of the following, which combination of size in pounds and distance in miles would qualify for free delivery?
A. Paul has 1,100 pounds of paper that requires 3 miles of travel.
B. Li Min has 1,500 pounds of paper that requires 107 miles of travel.
C. Amira has 1,800 pounds of paper that requires 94 miles of travel.
D. Jarles has 3,500 pounds of paper that requires 225 miles of travel.

CORRECT ANSWER: C DIFFICULTY LEVEL: 2
13. When Suraj goes to Roycefield golf course, he loses $20 \%$ of the (golf) balls he uses. When he goes to Hunterdon golf course, he loses $30 \%$ of the balls he uses. It costs Suraj $\$ 1.20$ to buy a ball. This weekend, Suraj is planning to use 25 balls at Roycefield and 30 balls at Hunterdon. If he only has $\$ 20$ to spend on balls, how many balls can he buy in order to guarantee that he will be able to replace the balls he loses this weekend?
A. 5
B. 10
C. 15
D. 20

CORRECT ANSWER: C DIFFICULTY LEVEL: 2
14. A technology store sells tablets and computers. In January they sell over 300 items, and more of those sales are tablets than computers. In February they sell exactly 100 tablets and 20 computers. The graph at left shows two equations related to this problem, where $t$ is the total tablet sales (in January and February combined), and $c$ is the total computer sales. Which of the following combinations could be the technology store's total sales?

A. 240 tablets and 100 computers
B. 360 tablets and 180 computers
C. 240 tablets and 260 computers
D. 120 tablets and 180 computers

## CORRECT ANSWER: B DIFFICULTY LEVEL: 2

15. Elena is designing a paint can with thickness $t$ millimeters and height $h$ centimeters. She calculates that the thickness of the can in milimeters must be at least 0.1 times the height of the can in centimeters in order to withstand pressure. Due to cost constraints, the cost of material used, $(0.2+t+0.5 h)$ cents, must be at most 12.2 cents. Which of the following systems of inequalities best models the relationship between height and thickness described above?
A. $\left\{\begin{array}{l}t \leq 12-\frac{h}{2} \\ 10 t \geq h\end{array}\right.$
B. $\left\{\begin{array}{l}t \leq 12-\frac{h}{2} \\ t \geq 10 h\end{array}\right.$
C. $\left\{\begin{array}{l}t \geq 12-\frac{h}{2} \\ 10 t \geq h\end{array}\right.$
D. $\left\{\begin{array}{l}t \geq 12-\frac{h}{2} \\ t \geq 10 h\end{array}\right.$

CORRECT ANSWER: A DIFFICULTY LEVEL: 2
16. Anna is considering three insurance options for her business, shown in the table below.

|  | Initial cost $(c)$ | Deductible $(d)$ |
| :--- | ---: | ---: |
| Option 1: | $\$ 1,425$ | $\$ 450$ |
| Option 2: | $\$ 1,700$ | $\$ 250$ |
| Option 3: | $\$ 1,975$ | $\$ 50$ |

She wants the total cost, $c+d$, to be at most $\$ 2,000$. She also wants the benefit, which is 9090 percent of $(10 c d)$, to be at least $\$ 12,400$. Which of the following option selections would fit Anna's plan?
A. Options 11 and 22 work
B. Only option 22 works
C. Only option 33 works
D. None of the above

## CORRECT ANSWER: A DIFFICULTY LEVEL: 2

17. Aaron is purchasing party hats and fake mustaches for an end of the school year party. He can spend at most $\$ 30$. Fake mustaches cost $\$ 3$ each, and party hats cost $\$ 2$ each. If he must purchase a combination of at least 15 mustaches and party hats, which of the following systems of inequalities best models the relationship between the number of mustaches, $m$, and party hats, $p$, described above?
A. $\left\{\begin{array}{l}m+p \geq 15 \\ 3 m+2 p \leq 30\end{array}\right.$
B. $\left\{\begin{array}{l}m+p \leq 15 \\ 3 m+2 p \geq 30\end{array}\right.$
C. $\left\{\begin{array}{l}3 m+2 p \geq 15 \\ m+p \leq 30\end{array}\right.$
D. $\left\{\begin{array}{l}3 m+2 p \leq 15 \\ m+p \geq 30\end{array}\right.$

CORRECT ANSWER: A DIFFICULTY LEVEL: 2
18. A company manufactures cellular phones and laptop computers. The company's daily production of cellular phones, $c$, must be more than 500,000 , and its daily production of laptop computers, $l$, must be more than 300,000 . If the maximum
capacity of the company's manufacturing center is no more than 950,000 total cellular phones and laptop computers, which of the following systems of inequalities best models the situation described above?
A. $\left\{\begin{array}{l}c-l>950,000 \\ c \geq 500,000 \\ l \geq 300,000\end{array}\right.$
B. $\left\{\begin{array}{l}c-l \leq 950,000 \\ c>500,000 \\ l>300,000\end{array}\right.$
C. $\left\{\begin{array}{l}c+l<950,000 \\ c \geq 500,000 \\ l \geq 300,000\end{array}\right.$
D. $\left\{\begin{array}{l}c+l \leq 950,000 \\ c>500,000 \\ l>300,000\end{array}\right.$

CORRECT ANSWER: D
DIFFICULTY LEVEL: 2
19. Tony is raising funds for his school soccer team by selling boxes of candy and t-shirts. His goal is to make more than $\$ 300$ dollars overall. Each box of candy that Tony sells earns him $\$ 15$, and each $t$-shirt sold earns him $\$ 20$. If Tony wants to sell at least as many t-shirts as boxes of candy, then which of the following systems of inequalities best models the relationship between the number of boxes of candy, $c$, and t-shirts, $t$, described above?
A. $\left\{\begin{array}{l}c+t>300 \\ 20 t \leq 15 c\end{array}\right.$
B. $\left\{\begin{array}{l}c+t>300 \\ 20 t \geq 15 c\end{array}\right.$
C. $\left\{\begin{array}{l}15 c+20 t>300 \\ t \geq c\end{array}\right.$
D. $\left\{\begin{array}{l}15 c+20 t>300 \\ t \leq c\end{array}\right.$

## CORRECT ANSWER: C

## DIFFICULTY LEVEL: 2

20. Arturo goes to his neighborhood store to purchase almonds and walnuts for an old family recipe. One pound of almonds costs $\$ 2$, and one pound of walnuts costs $\$ 4$. Arturo can spend at most $\$ 18$ on almonds and walnuts. The graph at left, in the $w a$-plane, relates the number of pounds, $w$, of walnuts to the number of pounds, $a$, of almonds which Arturo can purchase and have enough for his recipe. Which of the following amounts of walnuts and almonds can he purchase?

A. 2 pounds of walnuts and 11 pound of almonds
B. 33 pounds of walnuts and 77 pounds of almonds
C. 44 pounds of walnuts and 22 pound of almonds
D. 22 pounds of walnuts and 44 pounds of almonds

CORRECT ANSWER: D

## DIFFICULTY LEVEL: 2

$$
q \leq 4,000-5 p
$$

21. $p \geq 200$
$q \geq 0$
In a standard economic supply and demand graph, consumer surplus is defined as the area greater than or equal to the equilibrium price of a good and less than or equal to the demand line. The system of linear inequalities written and graphed at left, where $p$ represents price and $q$ represents the quantity of units that consumers will demand, shows the consumer surplus area for a tablet computer that recently entered the U.S. marketplace. What is the maximum quantity of the tablet that consumers will demand and still have it remain in the consumer surplus area of the graph?

A. 200
B. 800
C. 2800
D. 3000
22. Julia mows lawns in the summer for $\$ 15$ per lawn. It costs Julia between $\$ 2$ and $\$ 4$ to mow 1 lawn. If $l$ represents the number of lawns Julia mows, which graph correctly shades the possible values of Julia's net earnings, $d$, in dollars?
A.

B.

C.


CORRECT ANSWER: B
D.


DIFFICULTY LEVEL: 3
23. The florist needs at least $\frac{1}{3}$ gallons of nutrient-rich water for each bushel of flowers he buys. With $\$ 120$ to spend this week, the florist purchases $f$ bushels of flowers at $\$ 1.19$ per bushel and $w$ gallons of nutrient-rich water at $\$ 0.50$ per gallon.

The equations related to these two constraints are graphed at left. How many bushels of flowers and gallons of nutrient-rich water could he buy?

A. 120 bushels of flowers and 20 gallons of nutrient-rich water
B. 100 bushels of flowers and 80 gallons of nutrient-rich water
C. 60 bushels of flowers and 40 gallons of nutrient-rich water
D. 80 bushels of flowers and 10 gallons of nutrient-rich water
$\$ 14.60$ per hour. Each week, Cecília can work no more than 40 hours, but she needs to make at least $\$ 440$. In one week, Cecília works $a$ hours at the first job and $b$ hours at the second job. Which graph represents the number of hours that Cecília can work at each of her two jobs to satisfy these conditions?
A.

B.

C.

D.


CORRECT ANSWER: B

## DIFFICULTY LEVEL: 3

25. A landscaping company sells bags that hold up to 2.25 cubic feet $\left(f t^{3}\right)$ of mulch. The company guarantees that there is at least $2 f t^{3}$ of mulch inside each bag. The graph at left shows two equations related to this problem, where $b$ is the number of bags of mulch and $v$ is the cubic feet of mulch. Which of the following purchases
could have come from this company?

A. 12 bags of mulch containing $45 f t^{3}$ of mulch
B. 14 bags of mulch containing $40 \mathrm{ft}^{3}$ of mulch
C. 16 bags of mulch containing $35 \mathrm{ft}^{3}$ of mulch
D. 18 bags of mulch containing $30 \mathrm{ft}^{3}$ of mulch
26. A barge must carry steel pieces for a construction project such that the total weight of the steel pieces is under $1,500,000$ kilograms $(\mathrm{kg})$. Each steel piece is either a beam, which weighs 363 kg , or a connector plate, which weighs 6 kg . There must be at least 2 connector plates for each beam. If $b$ is the number of beams and $c$ is the number of connector plates, which of the following systems of inequalities must be true?
A. $363 b+6 c<1,500,000$ $b \leq 2 c$
B. $363 b+6 c<1,500,000$
$2 b \leq c$
C. $363 b+6 c \geq 1,500,000$
$b \geq 2 c$
D. $363 b+6 c \geq 1,500,000$
$2 b>c$
CORRECT ANSWER: B

## DIFFICULTY LEVEL: 3

27. A car dealership can have up to 90 cars on its lot. According to dealership predictions, when the average number of cars on the lot is 60 , then at most 480 cars are sold per year. Whenever the average number of cars on the lot increases by 1 , the dealership sells up to 2 more cars per year. Which of the following graphs represents the predicted car sales per year, $S$, based on the average number of cars on the lot, $c$ ?
A.
B.

C.

D.

28. The owners of an aquarium have recently built a new tank that can hold up to 110 fish. The owners wish to fill it with orange fish and blue fish. The orange fish are smaller, so they want at least 20 more orange fish than blue fish. Which of the following graphs represents the possible number of orange fish, $k$, and blue fish, $j$, that they can put in the tank?
A.

B.

C.

D.

CORRECT ANSWER: A
DIFFICULTY LEVEL: 3
29.In tennis, a player must win 6 games in order to win a set. However, winning 6 games does not guarantee that the player will win the set. If $g$ is the number of games
the player won and $s$ is the number of sets the player won, which of the following inequalities must be true?
A. $s \leq 6 g$
B. $s \geq 6 g$
C. $6 s \leq g$
D. $6 s \geq g$

CORRECT ANSWER: C

## DIFFICULTY LEVEL: 3

30. Kaylee and Mariana are runners. In 1 hour, Kaylee can run around the track 48.5 times and Mariana can run around the park trail 4 times. Let $t$ be the length of the track and $p$ be the length of the park trail, both in meters. If Kaylee is the faster runner, which of the following inequalities is true?
A. $48.5 p<4 t$
B. $48.5 p>4 t$
C. $4 p<48.5 t$
D. $4 p>48.5 t$

CORRECT ANSWER: C
DIFFICULTY LEVEL: 3
31. Rodolfo wants to determine how best to benefit from his weekly workouts. His goal is to burn at least 3300 calories per week from jogging and playing soccer. He can burn 700 calories each hour he spends jogging and 600 calories each hour he spends playing soccer. If Rodolfo's schedule permits him to spend at most 3 hours per week playing soccer and at most 5 total hours per week exercising, which of the following exercise schedules will allow him to meet his weekly goal?
A. 4 hours playing soccer and 1 hour jogging
B. 1 hour playing soccer and 5 hours jogging
C. 3 hours playing soccer and 2 hours jogging
D. 2 hours playing soccer and 3 hours jogging

## CORRECT ANSWER: D

DIFFICULTY LEVEL: 3
32. Roberto plans to start a new job. In preparation, he decides that he should spend no more than 30 hours per week on the job and homework combined. If Roberto wants to have at least 2 homework hours for every 1 hour at his job, what is the maximum number of hours that he should spend at his job each week?
A. 9 hours
B. 10 hours
C. 20 hours
D. 21 hours

CORRECT ANSWER: B

## DIFFICULTY LEVEL: 3

33. A rancher wants to build a rectangular pen for her animals. She decides that the length, $l$, of one side of the pen should be at most 60 feet, the width, $w$, of one side of the pen should be at least 30 feet, and the perimeter of the pen should be at most 200 feet. Which of the following systems of inequalities best models the situation described above?
A. $\left\{\begin{array}{l}l+w \leq 200 \\ w \geq 30 \\ l \leq 60\end{array}\right.$
B. $\left\{\begin{array}{l}l+w \geq 200 \\ w \leq 30 \\ l \geq 60\end{array}\right.$
C. $\left\{\begin{array}{l}l+w \leq 100 \\ w \geq 30 \\ l \leq 60\end{array}\right.$
D. $\left\{\begin{array}{l}2 l+2 w \geq 200 \\ w \geq 30 \\ l \leq 60\end{array}\right.$

CORRECT ANSWER: C

## DIFFICULTY LEVEL: 3

34. A food scientist is designing a prototype for a cylindrical ice cream cone. The radius, $r$, of the cone must be at most 1.3 inches, and the height, $h$, of the cone must be at least 5 inches. Finally, the height can be at most 4.5 times the radius. Which of the following systems of inequalities best models the relationship between the height and radius of the cone?
A. $\left\{\begin{array}{l}4.5 h \leq r \\ r \leq 1.3 \\ h \geq 5\end{array}\right.$
B. $\left\{\begin{array}{l}h \leq 4.5 r \\ r \leq 1.3 \\ h \geq 5\end{array}\right.$
C. $\left\{\begin{array}{l}h \leq \frac{r}{4.5} \\ r \leq 1.3 \\ h \geq 5\end{array}\right.$
D. $\left\{\begin{array}{l}\frac{h}{4.5} \geq r \\ r \geq 1.3 \\ h \leq 5\end{array}\right.$

CORRECT ANSWER: B
DIFFICULTY LEVEL: 3
35. A tennis club is organizing group lessons. The club supplies 40 new balls for each player which cost $\$ 1$ each. Each player pays $\$ 300$ for the lessons. The club must pay each instructor $\$ 1,000$ for conducting the lessons, and there must be at least 1 instructor for every 6 players. Which amount of players and instructors meets these
requirements and still gives the club a net profit?
A. 6 players and 2 instructors
B. 10 players and 3 instructors
C. 13 players and 2 instructors
D. 16 players and 3 instructors

CORRECT ANSWER: D

## DIFFICULTY LEVEL: 4

36. A bottle weighs 50 grams and holds up to 2 liters of liquid. A chemist is filling the bottle with $x$ grams of liquid ethanol and $y$ grams of liquid water. Ethanol has a density of 789 grams per liter and water has a density of 1,000 grams per liter. The chemist wants the mass of the filled bottle to be less than 1,800 grams. Which of the following systems of inequalities best models the situation described above?
A. $\left\{\begin{array}{l}x+y<1,750 \\ 789 x+1,000 y \leq 2\end{array}\right.$
B. $\left\{\begin{array}{l}x+y<1,750 \\ \frac{x}{789}+\frac{y}{1,000} \leq 2\end{array}\right.$
C. $\left\{\begin{array}{l}x+y<1,850 \\ 789 x+1,000 y \leq 2\end{array}\right.$
D. $\left\{\begin{array}{l}x+y<1,850 \\ \frac{x}{789}+\frac{y}{1,000} \leq 2\end{array}\right.$

CORRECT ANSWER: B
DIFFICULTY LEVEL: 4
37. Derin is travelling abroad with a $\$ 25$ calling card, which was a gift from her grandmother. The rate to call Japan, where her boyfriend is living, is $\$ 0.19$ per minute. Her family is in Turkey, where the calling rate is $\$ 0.12$ per minute. Derin promised her grandmother she would spend at least 30 of her minutes on keeping in touch with family. Which of the following systems of inequalities represents the relationship between $J$, the number of minutes Derin could call Japan, and $T$, the number of
minutes Derin could call Turkey?
A. $\begin{aligned} & T \leq 208-1.6 J \\ & T+J \geq 30\end{aligned}$
B. $T \leq 25-0.19 J$
$T+J \geq 30$
C. $T \leq 208-1.6 J$
$T \geq 30$
D. $\begin{aligned} & T \leq 25-0.19 J \\ & T \geq 30\end{aligned}$
$T \geq 30$
CORRECT ANSWER: C
DIFFICULTY LEVEL: 4
38. Manoj runs a business at a baseball stadium. This month, with a budget of $\$ 17,000$, Manoj buys $p$ pounds of peanuts at $\$ 1.10$ per pound and pays his salespeople $\$ 200$ each. There are $s$ salespeople in total, and it is predicted that each can sell a maximum of 1,875 pounds of peanuts this month. Manoj will not buy more peanuts than what he predicts his salespeople can sell. Which of the following systems of inequalities represents this situation?
A. $\$ 1,7000<\$ 200 \mathrm{~s}+\frac{p}{\$ 1.10}$
$1,875 \mathrm{~s} \leq \mathrm{p}$
B. $\$ 1,7000<\$ 200 s+\$ 1.10 p$
$s \geq 1,875$
C. $\$ 1,7000 \geq \$ 200 \mathrm{~s}+\frac{p}{\$ 1.10}$
$s \leq 1,875 p$
D. $\$ 1,7000 \geq \$ 200 s+\$ 1.10 p$
$1,875 s \geq p$
CORRECT ANSWER: D
39. A used car dealer has 20 vehicles, all cars and trucks. He would like to paint and clear coat as many of them as possible with the 260 liters of paint and 300 liters of clear coat that he has. It takes 13.2 liters of paint and 9.5 liters of clear coat for one car. It takes 1.5 times those amounts for one truck. Given the relevant equations graphed at left, which of the following could be the amount of cars and trucks that received paint and clear coat?

A. 10 cars and 6 trucks
B. 6 cars and 10 trucks
C. 14 cars and 11 trucks
D. 11 cars and 14 trucks

CORRECT ANSWER: A

## DIFFICULTY LEVEL: 4

40. Some zoo monkeys are on a diet of fruit and nuts. Fruit has about 13.3 grams (g) of sugar per cup and 1.36 g of protein per cup. Nuts have about 4.04 g of sugar per cup and 15.56 g of protein per cup. Each monkey must get between 70 g and 90 g of sugar per day and at least 85 g of protein per day. Which of the following daily diets fits the
monkeys' needs?
A. 0 cups of fruit and 16 cups of nuts
B. 4 cups of fruit and 8 cups of nuts
C. 8 cups of fruit and 4 cups of nuts
D. 16 cups of fruit and 0 cups of nuts

CORRECT ANSWER: B
DIFFICULTY LEVEL: 4
41. A memory chip is being designed to hold a number of transistors and heat sinks. The transistors hold memory while the heat sinks cool the chip. There must be at least one heat sink for every 2,000 transistors to prevent overheating. Also, each transistor has an area of $2.0 \times 10^{-10} \mathrm{~mm}^{2}$ (square millimeters), each heat sink has an area of $3.6 \times 10^{-6} \mathrm{~mm}^{2}$, and the total area of transistors and heat sinks must be at most $2 \mathrm{~mm}^{2}$. What is the approximate maximum number of transistors that the chip can hold according to this design?
A. $2.78 \times 10^{2}$

B $\cdot 5.56 \times 10^{5}$
C. $1.0 \times 10^{9}$
D. $1.0 \times 10^{10}$

CORRECT ANSWER: C
DIFFICULTY LEVEL: 4
42. A business analyst is deciding the amount of time allotted to each employee for meetings and training. He wants the sum of meeting and training time to be no more than 16 hours per month. Also, there should be at least one training hour for every two meeting hours. Finally, there should be at least 2 meeting hours per month to discuss short-term goals. What is the difference between the maximum and minimum number of monthly training hours that could be allotted to an employee?
A. 10 hours
B. 13 hours
C. 14 hours
D. 16 hours
43. The supply and demand curves for a product are given by functions $S$ and $D$, respectively. For a given number of units, $\mathrm{Q}, \mathrm{S}$ is the minimum price, in dollars, that the supplier should accept. D is the maximum price, in dollars, where consumers will purchase that number of units.

$$
\begin{aligned}
& S(Q)=45+0.04 Q \\
& D(Q)=110-0.003 Q
\end{aligned}
$$

For the above equations, which of the following combinations of price and quantity fall between the maximum consumer price and minimum supplier price?
A. 500 units at $\$ 105$
B. 1,000 units at $\$ 80$
C. 1,500 units at $\$ 110$
D. 2,450 units at $\$ 110$

CORRECT ANSWER: A
DIFFICULTY LEVEL: 4
44. A bakery needs to make cakes for Mother's Day, and must prepare by storing ingredients. Each cake is made from 4 cups of batter and $\frac{7}{2}$ cups of frosting. The bakery has storage for up to 150 cups of ingredients. The two equations related to these constraints are graphed at left. If the bakery wants no batter leftover, which of the following could be the volume of batter and frosting that they store?

A. 80 cups of batter and 60 cups of frosting
B. 90 cups of batter and 70 cups of frosting
C. 80 cups of batter and 80 cups of frosting
D. 70 cups of batter and 70 cups of frosting

CORRECT ANSWER: D

## Solving systems of linear equations

1. $\mathrm{z}+\mathrm{w}-3=\mathrm{k}$
$6 \mathrm{z}-10 \mathrm{w}=8$
Consider the system of equations above, where k is a constant. For which value of k are there infinitely many ( $\mathrm{w}, \mathrm{z}$ ) solutions?
A. $-\frac{19}{5}$
B. 5
C. 8
D. None of the above

Correct answer: D Difficulty level: 2
2. $-5 \mathrm{x}-4 \mathrm{y}=2 a$
$4 x-5 y=2$
Which of the following choices of $a$ will result in a system of linear equations with exactly one solution?
A. $a$ can be any number
B. $a$ can be any number except 0.8
C. $a$ can be any number except -0.8
D. $a=0.8$

Correct answer: A Difficulty level: 2
3. $\frac{1}{2}\left(x+\frac{2}{3}\right)-1=2\left(y+\frac{1}{3}\right)-\frac{1}{3} \quad(x-2)-4\left(y+\frac{1}{2}\right)=-2$

Consider the system of equations above. Which of the following statements about this system is true?
A. There is only one $(x, y)$ solution and $x+y$ is positive.
B. There is only one $(x, y)$ solution and $x+y$ is negative.
C. There are infinitely many $(x, y)$ solutions.
D. There are no $(\mathrm{x}, \mathrm{y})$ solutions.

Correct answer: C Difficulty level: 2
4. $\frac{2}{3}(x+1)-\frac{4}{5} y=\frac{1}{3} \quad \frac{2}{5} x+\frac{1}{3}(2 y+1)=\frac{1}{5}$

Consider the system of equations above. Which of the following statements is true?
A. There is only one solution ( $x, y$ ) and $x+y$ is positive.
B. There is only one solution $(x, y)$ and $x+y$ is negative.
C. There are infinitely many solutions.
D. There are no solutions.

Correct answer: B Difficulty level: 2
5. $\quad 1.70 \mathrm{p}-0.34 \mathrm{q}=0$
$0.17(\mathrm{q}+1)-0.85(\mathrm{p}-1)=0$
Consider the system of equations above. How many $(p, q)$ solutions does this system have?
A. 0
B. 1
C. Infinitely many
D. None of the above

Correct answer: A Difficulty level: 2
6. $3 s+2 t-3=c$
$-7 \mathrm{~s}-5 \mathrm{t}=4$
Consider the system of equations above, where c is a constant. For which value of c is there exactly one $(s, t)$ solution where $s=-1$ ?
A. -4.8
B. $4 \frac{4}{7}$
C. 18
D. None of the above

Correct answer: A Difficulty level: 2
7. $0.7 \mathrm{a}-0.8 \mathrm{~b}=-0.1$
$\mathrm{a}-1.4=-6(\mathrm{~b}-0.1)$
Consider the system of equations above. If $(a, b)$ is the solution to the system, then what is the value of the sum of $a$ and $b$ ?
A. -0.5
B. -0.1
C. 0.1
D. 0.5

Correct answer: D Difficulty level: 2
8. $6(1-a)=3(a-b)+1$
$4(b-2)=3 a$
Consider the system of equations above. If $(a, b)$ is the solution to the system, then what is the value of $a-b$ ?
A. $-\frac{1,276}{243}$
B. $\frac{29}{9}$
C. $\frac{44}{27}$
D. $\frac{1,276}{243}$

Correct answer: D Difficulty level: 2
9. $7 \mathrm{p}=9(\mathrm{p}+\mathrm{q})+11$
$9 q+3=-4(7 q+p)$
Consider the system of equations above. If ( $p, q$ ) is the solution to the system, then what is the value of $\mathrm{p}+\mathrm{q}$ ?

Correct answer: -9 Difficulty level: 2
10. $-0.2 x+b y=7.2$
$5.6 x-0.8 y=4$
Consider the system of equations above. For what value of $b$ will the system have exactly one solution ( $\mathrm{x}, \mathrm{y}$ ) with $\mathrm{x}=2$ ? Round the answer to the nearest tenth.

Correct answer: 0.8 Difficulty level: 3
11. $-4 a-5 b-4=-21$
$-2 b+5 a-11=-9$
Consider the system of equations above. What is the value of $-2 a-b$ ?
A. -5
B. $-\frac{1}{3}$
C. $\frac{1}{3}$
D. 5

Correct answer: A Difficulty level: 3
12. $2 \mathrm{x}-1=\mathrm{y}$
$3 \mathrm{x}-1=\mathrm{y}$
Consider the system of equations above. Which of the following statements about this system is true?
A. There is only one $(x, y)$ solution and $y$ is positive.
B. There is only one $(x, y)$ solution and $y$ is negative.
C. There are infinitely many $(x, y)$ solutions.
D. There are no $(x, y)$ solutions.

Correct answer: B Difficulty level: 3
13. $a\left(\frac{y}{2}-\frac{3}{2} x+1\right)=\frac{4}{3} y-\frac{1}{2} x+\frac{5}{6} \quad \frac{5}{6} y-\left(\frac{5}{6} x+\frac{5}{2}\right)=0$

Consider the system of equations above, where a is a constant. For which value of a is ( $x$, $y)=(4,1)$ a solution?
A. $-\frac{34}{27}$
B. $-\frac{1}{27}$
C. $\frac{34}{9}$
D. None of the above

Correct answer: D Difficulty level: 3
14. $44(\mathrm{j}+2 \mathrm{k})=12$
$22 \mathrm{k}=-11 \mathrm{j}+16$
Consider the system of equations above. How many solutions ( $\mathrm{j}, \mathrm{k}$ ) does this system have?
A. 0
B. Exactly 1
C. Exactly 2
D. Infinitely many

Correct answer: A Difficulty level: 3
15. $1.5 \mathrm{a}-4.5 \mathrm{~b}=3(\mathrm{a}+\mathrm{b})$
$5.5 \mathrm{~b}=5(\mathrm{~b}-\mathrm{a})+2.5 \mathrm{a}$
Consider the system of equations above. If $(a, b)$ is the solution to the system, then what is the value of $b-a$ ?

Correct answer: 0 Difficulty level: 3
16. $5 x-2 y=6$
$10 x-4 y=c$
Which of the following choices of c will result in a system of linear equations with no solutions?
A. $\mathrm{c}=12$
B. c can be any number other than -12
C. c can be any number other than 12
D. c can be any number

Correct answer: C Difficulty level: 3
17. $-x=-6 y-7$
$x-6 y=k$

Consider the system of equations above. Which of the following choices of k will result in a system of equations with infinitely many solutions?
A. Any number
B. Any number except 7
C. 7
D. -7

Correct answer: C Difficulty level: 3
18. $\frac{6}{5} p+k q=\frac{4}{5} \quad q=\frac{3}{5} p-\frac{2}{5}$

Consider the system of equations above, where k is a constant. For which value of k is there no ( $\mathrm{p}, \mathrm{q}$ ) solutions?
A. -2
B. 0
C. 2
D. None of the above

Correct answer: D Difficulty level: 4
19. $-11 y=6(z+1)-13 y$
$4 y-24=c(z-1)$
For what value of $c$ does the above system of linear equations in the variables $y$ and $z$ have infinitely many solutions?

Correct answer: 12 Difficulty level: 4
20. $2\left(x-\frac{1}{3}\right)-\frac{3}{2}\left(y-\frac{1}{6}\right)=0 \quad 3\left(y-\frac{1}{2}\right)+\frac{8}{3}\left(x-\frac{1}{6}\right)=0$

Consider the system of equations above. If $(x, y)$ is the solution to the system, then what is the value of the sum of $x$ and $y$ ?
A. $\frac{5}{6}$
B. $\frac{25}{36}$
C. $\frac{2}{3}$
D. None of the above

Correct answer: B Difficulty level: 4
21. $-5.1 x+3 y=1.2$
$3.2 x-8 y=b$
Which of the following choices of $b$ will result in a system of linear equations with exactly
one solution?
A. b can be any number
B. b can be any number except 1.2
C. b can be any number except -1.2
D. $b=1.2$

Correct answer: A Difficulty level: 4
22. $0.6=1.5(\mathrm{a}+\mathrm{c}(\mathrm{b}+0.8))$
$-0.2=-2.5(b-0.4(1.2-1.5 a))$
Consider the system of equations above, where c is a constant. For which value of ccc are there no $(a, b)$ solutions?
A. 0
B. $\frac{5}{17}$
C. $\frac{5}{3}$
D. None of the above

Correct answer: C Difficulty level: 4
23. $a(p-q)=1$
$p=2 q-1$
Consider the system of equations above, where $a$ is a constant. For which value of $a$ is $(p$, q) $=(1,1)$ a solution?
A. 0
B. 1
C. 2
D. None of the above

Correct answer: D Difficulty level: 4
24. $a\left(y-\frac{1}{3}\right)+\frac{x}{2}=0 \quad 3 y-x-1=0$

Consider the system of equations above, where a is a constant. For which value of a are there infinitely many ( $\mathrm{x}, \mathrm{y}$ ) solutions?
A. $-\frac{3}{2}$
B. $\frac{5}{6}$
C. 3
D. None of the above

Correct answer: A Difficulty level: 4
25. $a y=2 x+1$
$y=2 x+2$
Consider the system of equations above, where a is a constant. For what value of a are there no ( $\mathrm{x}, \mathrm{y}$ ) solutions?

Correct answer: 1 Difficulty level: 4
26. $5.2 \mathrm{~s}+0.1 \mathrm{r}=0$
$0.7(\mathrm{r}+0.2)+3.2=-3 \mathrm{~s}$
Consider the system of equations above. If $(r, s)$ is the solution to the system, then what is the value of $r+s$ ? Round the answer to the nearest tenth.

Correct answer: -5.1 Difficulty level: 4
27. $-6.4 x=4 y+2.1$
$k y+3.2 x=5.8$
For what value of $k$ does the above system of linear equations in the variables $x$ and $y$ have no solutions?

Correct answer: 2 Difficulty level: 4
28. $\frac{3}{2} x-3 y=\frac{1}{4} \quad 2 x-\frac{13}{3} y=\frac{1}{9}$

Consider the system of equations above. If ( $x, y$ ) is the solution to the system, then what is the value of the product of $x$ and $y$ ?
A. -1
B. 1
C. $\frac{13}{6}$
D. None of the above

Correct answer: B Difficulty level: 4

## Systems of linear equations word problems

1. The owner of a landscaping company is developing a proposal to maintain the grounds of a building. It is estimated that 75 gardening hours and 25 foreman hours will be required. The total budget for these hours is $\$ 1600$. The hourly wage for a foreman is $30 \%$ more than a gardener plus an additional $\$ 1.65$ per hour. Which of the following systems of equations can be used to determine the hourly wages of a gardener, g , and a foreman, f , so the total wages are $\$ 1600$ ?
A. $25 \mathrm{~g}+75 \mathrm{f}=1600$
$\mathrm{f}=1.3 \mathrm{~g}+1.65$
B. $25 \mathrm{f}+75 \mathrm{~g}=1600$
$\mathrm{f}=1.3 \mathrm{~g}+1.65$
C. $25 \mathrm{~g}+75 \mathrm{f}=1600$
$\mathrm{g}=1.3 \mathrm{f}+1.65$
D. $25 \mathrm{f}+75 \mathrm{~g}=1600$ $\mathrm{g}=1.3 \mathrm{f}+1.65$

Correct answer: B Difficulty level: 2
2. Devin is a landscaper who needs to prepare different types of grass seed for his customers' yards. Bluegrass seed costs $\$ 2.00$ per pound while drought-resistant seed costs $\$ 3.00$ per pound. If for a particular day the two types of grass seed totaled $\$ 68.00$ and together weighed 25 pounds, how many pounds of bluegrass seed did Devin prepare?
A. 4 pounds of bluegrass seed and 21 pounds of drought-resistant seed
B. 7 pounds of bluegrass seed and 18 pounds of drought-resistant seed
C. 18 pounds of bluegrass seed and 7 pounds of drought-resistant seed
D. 21 pounds of bluegrass seed and 4 pounds of drought-resistant seed

Correct answer: B Difficulty level: 2
3. Ricardo had two types of homework assignments for his college math class. The amount of mmm mini assignments he had was one fewer than twice the amount of $l$ long assignments he had. If he had a total of 46 mini and long assignments, which of the following systems of equations can be used to find out how any mini and long assignments he had?
A. $m=2 l-1$
$\mathrm{m}+l=46$
B. $\mathrm{m}=2 l-1$
$\mathrm{m}=l+46$
C. $l=2 \mathrm{~m}-1$
$\mathrm{m}+l=46$
D. $l=2 \mathrm{~m}-1$
$\mathrm{m}=l+46$

Correct answer: A Difficulty level: 2
4. One Saturday, a butcher sells meat at a local farmer's market and makes a total number of dollars from selling a specific number of pounds of beef at $\$ 6.00 \backslash \$ 6.00 \$ 6.00$ per pound as well as $\$ 7.00 \backslash \$ 7.00 \$ 7.00$ from selling pork. On Sunday, she makes the same amount of money from selling an equivalent bbb pounds of beef at $\$ 4.00 \backslash \$ 4.00 \$ 4.00$ per pound as well as $\$ 5.00 \backslash \$ 5.00 \$ 5.00$ from selling pork. Which system of equations can be used to find out how many bbb pounds of beef she made for a total of ddd dollars?
A. $d=4 b+7$
$d=6 b+5$
B. $d=6 b+7$
$d=4 b+5$
C. $b=4 d+7$
$b=6 d+5$
D. $b=6 d+7 b=4 d+5$

Correct answer: B Difficulty level: 2
5. A piece of glass with an initial temperature of $99^{\circ} \mathrm{C}$ is cooled at a rate of $3.5^{\circ} \mathrm{C}$ per minute. Concurrently, a piece of copper with an initial temperature of $0^{\circ} \mathrm{C}$ is heated at $2.5^{\circ} \mathrm{C}$ per minute. Which of the following systems of equations can be used to solve for the temperature, $T$, in degrees Celsius, and the time, $m$, in minutes, when the glass and copper reach the same temperatures?
A. $\mathrm{T}=99+3.5 \mathrm{~m}$
$\mathrm{T}=2.5 \mathrm{~m}$
B. $T=99-3.5 \mathrm{~m}$
$\mathrm{T}=2.5 \mathrm{~m}$
C. $T=99+2.5 \mathrm{~m}$
$\mathrm{T}=3.5 \mathrm{~m}$
D. $T=99-2.5 \mathrm{~m}$ $\mathrm{T}=3.5 \mathrm{~m}$

Correct answer: B Difficulty level: 2
6. A vegetable stand sells p pumpkins for $\$ 5.00$ each and s squashes for $\$ 3.00$ each. On Monday, the stand sold 6 more squashes than pumpkins and made a total of $\$ 98.00$. Which system of equations can be used to determine the number of pumpkins and squashes sold?
A. $3 p+5 \mathrm{~s}=98$
$\mathrm{s}=\mathrm{p}+6$
B. $3 p+5 s=98$
$\mathrm{p}=\mathrm{s}+6$
C. $5 \mathrm{p}+3 \mathrm{~s}=98$
$\mathrm{s}=\mathrm{p}+6$
D. $5 \mathrm{p}+3 \mathrm{~s}=98$
$\mathrm{p}=\mathrm{s}+6$

## Correct answer: C Difficulty level: 3

7. Mikayla is the communications director for a politician and has recommended that a total of 41 talks are given by the politician before election day. She also recommends a total of 9 more formal speeches, $s$, than informal talks, $t$. Which of the following systems of equations can be used to find out how many formal speeches versus informal talks she had?
A. $\mathrm{t}=\mathrm{s}+9$
$\mathrm{s}+\mathrm{t}=41$
B. $\mathrm{t}=\mathrm{s}+9$
$\mathrm{s}=\mathrm{t}-41$
C. $\mathrm{s}=\mathrm{t}+9$
$s^{+}+t=41$
D. $\mathrm{s}=\mathrm{t}+9$
$\mathrm{s}=\mathrm{t}-41$

Correct answer: C Difficulty level: 3
8. Tickets for a concert were $\$ 5$ for each child and $\$ 8$ for each adult. At one of the concerts, each adult brought 4 children with them, and 10 children attended without an adult. The total ticket sales were $\$ 1730$. Which of the following systems of equations can be solved to determine the number of children, c , and adults, a, who attended the concert?
A. $5 \mathrm{c}+8 \mathrm{a}=1730$
$4 a+10=c$
B. $5 \mathrm{c}+8 \mathrm{a}=1730$
$4 \mathrm{a}-10=\mathrm{c}$
C. $8 c+5 a=1730$
$4 a+10=c$
D. $8 c+5 a=1730$
$4 a-10=c$

Correct answer: A Difficulty level: 3
9. Today, the population of Canyon Falls is 22,500 and the population of Swift Creek is 15,200 . The population of Canyon Falls is decreasing at the rate of 740 people each year while the population of Swift Creek is increasing at the rate of 1,500 each year. Assuming these rates continue into the future, in how many years from today will the population of Swift Creek equal twice the population of Canyon Falls?
A. 9 years
B. 10 years
C. 11 years
D. 12 years

Correct answer: B Difficulty level: 3
10. The owner of a health food store is developing a new product that consists of peanuts and raisins. Raisins cost $\$ 2.50$ per pound and peanuts cost $\$ 3.50$ per pound. The owner wants to create 20 pounds of the product that cost $\$ 3.03$ per pound. Which of the following systems of equations can be used to determine the number of pounds of peanuts, $p$, and the number of pounds of raisins, $r$, that should be combined?
A. $\mathrm{p}-\mathrm{r}=20 \quad \frac{2.50 \mathrm{p}+3.50 \mathrm{r}}{20}=3.03$
B. $\mathrm{p}+\mathrm{r}=20 \quad \frac{2.50 \mathrm{p}+3.50 \mathrm{r}}{20}=3.03$
C. $\mathrm{p}-\mathrm{r}=20 \quad 2.50 p+3.50 r=3.03$
D. $\mathrm{p}+\mathrm{r}=20 \quad 2.50 p+3.50 r=3.03$

Correct answer: B Difficulty level: 3
11. Jerry has a large car which holds 22 gallons of fuel and get 20 miles per gallon. Kate has a smaller car which holds 16.5 gallons of fuel and gets 30 miles per gallon. If both cars have a full tank of fuel now and drive the same distance, in how many miles will the remaining fuel in each tank be the same?
A. 320
B. 325
C. 330
D. 335

Correct answer: C Difficulty level: 4
12. Paulo's economics course requires two papers--one long and one short--throughout the semester. The number of pages, 1 , in the long paper is one more than two times the number of pages, $s$, in the short paper. If the total number of pages for both papers is 40 , how many pages must be in the long paper?
$\square$ pages

Correct answer: 27 Difficulty level: 4
13. A charity is planning a raffle to raise money. There are 125 regular tickets and 50 premium tickets. The cost of a premium ticket is $25 \%$ more than a regular ticket plus an additional $\$ 1.50$. The raffle organizers expect to sell all of the tickets, and they want to collect $\$ 1,950$ from the ticket sales. Which of the following systems of equations can be used to determine the price, $p$, of each premium ticket and the price, $r$, of each regular ticket?
A. $50 \mathrm{p}+125 \mathrm{r}=1950$
$\mathrm{p}-1.25 \mathrm{r}=1.50$
B. $50 \mathrm{p}+125 \mathrm{r}=1950$
$\mathrm{p}-1.50 \mathrm{r}=1.25$
C. $125 \mathrm{p}+50 \mathrm{r}=1950$

$$
\mathrm{p}-1.25 \mathrm{r}=1.50
$$

D. $125 \mathrm{p}+50 \mathrm{r}=1950$ $\mathrm{p}-1.50 \mathrm{r}=1.25$

Correct answer: A Difficulty level: 4
14. The length of a rectangular swimming pool is twice the width. If the perimeter is 120 feet, then what is the width in feet?
$\square$ feet

Correct answer: 20 Difficulty level: 4
15. For a high school dinner function for teachers and students, the math department bought 6 cases of juice and 1 case of bottled water for a total of $\$ 135$. The science department bought 4 cases of juice and 2 cases of bottled water for a total of $\$ 110$. How much did a case of juice cost?
A. $\$ 12.50$
B. $\$ 15.00$
C. $\$ 20.00$
D. $\$ 25.00$

Correct answer: C Difficulty level: 4

## Part I solving quadratic equations

1. Which of the following could be the factored form of the polynomial shown below?
$x^{2}+3 x-18$
A. $(x-3)(x+6)$
B. $(x+3)(x-6)$
C. $(x-3)(x-6)$
D. $(x+3)(x+6)$

Correct answer: A difficult degree: 1
2. Which of the following could be the factored form of the polynomial shown below?
$x^{2}+16 x+60$
A. $(x+6)(x+10)$
B. $(x+6)(x-10)$
C. $(x-6)(x+10)$
D. $(x-6)(x-10)$

Correct answer: A difficult degree: 1
3. Which of the following could be the factored form of the polynomial shown below?
$x^{2}+12 x+27$
A. $(x-3)(x+9)$
B. $(x+3)(x-9)$
C. $(x-3)(x-9)$
D. $(x+3)(x+9)$

Correct answer: D difficult degree: 1
4. Which of the following could be the factored form of the polynomial shown below?
$x^{2}-x-6$
A. $(x-3)(x+2)$
B. $(x+3)(x+2)$
C. $(x-3)(x-2)$
D. $(x+3)(x-2)$

Correct answer: A difficult degree: 1
5. Which of the following could be the factored form of the polynomial shown
below?
$x^{2}+3 x-28$
A. $(x+7)(x-4)$
B. $(x-7)(x-4)$
C. $(x+7)(x+4)$
D. $(x-7)(x+4)$

Correct answer: A difficult degree: 1
6. $100-121 k^{2}=0$

What are the solutions to the equation above?
A. $k=\frac{100}{121}$
B. $\mathrm{k}=-\frac{100}{121}$ and $\mathrm{k}=\frac{100}{121}$
C. $\mathrm{k}=\frac{10}{11}$
D. $\mathrm{k}=-\frac{10}{11}$ and $\mathrm{k}=\frac{10}{11}$

Correct answer: D difficult degree: 2
7. $(2 x-3)(x+4)=0$

Let $x=a$ and $x=b$ be the solutions to the equation above. What is the value of $-a-b$ ?
Correct answer: 5/2 difficult degree: 2
8. $0=(2 y-1)(8-y)$

Let $y=u$ and $y=d$ be the solutions to the equation above. What is the value of $u \cdot d$ ?
Correct answer: 4 difficult degree: 2
9. $(2 x+5)(-m x+9)=0$

In the equation above, $m$ is a constant. If the equation has the solutions $x=-\frac{5}{2}$ and $x=\frac{3}{2}$, what is the value of $m$ ?

Correct answer: 6 difficult degree: 2
10. $\left(x+\frac{13}{2}\right)\left(x-\frac{13}{2}\right)=0$

How many distinct real solutions does the equation above have?
A. 0
B. 1
C. 2
D. 4

Correct answer: C difficult degree: 2
11. $\frac{2}{3} x^{2}-\frac{1}{2} x-\frac{3}{4}=0$

Let $\mathrm{x}=\mathrm{w}$ and $\mathrm{x}=\mathrm{z}$ be the solutions to the equation above. What is the value of $\mathrm{w}+\mathrm{z}$ ?
A. $-\frac{3}{2}$
B. $-\frac{3}{4}$
C. 0
D. $\frac{3}{4}$

Correct answer: D difficult degree: 3
12. $2 x^{2}-\frac{11}{2} x-\frac{3}{2}=0$

What are the solutions to the equation above?
A. $\mathrm{x}=-\frac{1}{4}$ and $x=2$
B. $\mathrm{x}=-\frac{1}{4}$ and $x=3$
C. $\mathrm{x}=2$ and $x=3$
D. $\mathrm{x}=-\frac{1}{4}, \mathrm{x}=2$, and $x=3$

Correct answer: B difficult degree: 3
13. $(t+15)^{2}+5=0$

How many distinct real solutions does the equation above have?
A. 0
B. 1
C. 2
D. 4

Correct answer: A difficult degree: 3
14. $x^{2}-13 x+30=0$

What are the solutions to the equation above?
A. $x=-15$ and $x=2$
B. $x=-10$ and $x=-3$
C. $x=3$ and $x=10$
D. $x=-2$ and $x=15$

Correct answer: C difficult degree: 3
15. $2 x^{2}+5 x-k=0$

In the equation above, $k$ is a constant. For what value of $k$ does the equation have exactly one distinct real solution?
A. $-\frac{25}{8}$
B. $-\frac{5}{4}$
C. $\frac{5}{4}$
D. $\frac{25}{8}$

Correct answer: A difficult degree: 3
16. $(t-10)^{2}-16=0$

What are the solutions to the equation above?
A. $t=4$ and $t=36$
B. $t=6$ and $t=14$
C. $t=10$ and $t=-16$
D. $t=10$ and $t=16$

Correct answer: B difficult degree: 3
17. $x-1=(2-x)^{2}$

What are the solutions to the equation above?
A. $x=0$
B. $x=\frac{5-\sqrt{5}}{2}$ and $x=\frac{5+\sqrt{5}}{2}$
C. $x=\frac{-1-\sqrt{21}}{2}$ and $x=\frac{-1+\sqrt{21}}{2}$
D. The equation has no real solutions.

Correct answer: B difficult degree: 3
18. $-\frac{1}{2}(t-3)+t^{2}=0$

How many distinct real solutions does the equation above have?
A. 0
B. 1
C. 2
D. 4

Correct answer: A difficult degree: 3
19. $-7(x-8)^{2}=-63$

Let $x=k$ and $x=/$ be solutions to the equation above. What is the value of $k \cdot /$ ?
Correct answer: 55 difficult degree: 3
20. $a x^{2}+5 x+2=0$

In the equation above, $a$ is a constant. If the equation has the solutions $x=-2$ and $x=-\frac{1}{2}$, what is the value of $a$ ?

Correct answer: 2 difficult degree: 3
21. $3 n^{2}=27$

What are the solutions to the equation above?
A. $n=\sqrt{3}$
B. $n=3$
C. $n=-\sqrt{3}$ and $n=\sqrt{3}$
D. $n=-3$ and $n=3$

Correct answer: D difficult degree: 3
22. Which of the following quadratic equations has exactly one distinct real solution?
A. $\frac{9}{16} x^{2}-3 x-4=0$
B. $\frac{9}{16} x^{2}-3 x+4=0$
C. $\frac{16}{25} x^{2}-25=0$
D. $\frac{16}{25} x^{2}+25=0$

Correct answer: B difficult degree: 3
23. $\left(v-\frac{5}{3}\right)^{2}=49$

What are the solutions to the equation above?
A. $v=-\frac{142}{3}$ and $v=\frac{152}{3}$
B. $v=-44$ and $v=54$
C. $v=-2$ and $v=12$
D. $v=-\frac{16}{3}$ and $v=\frac{26}{3}$

Correct answer: D difficult degree: 3
24. $(1-a)+3(1-a)^{2}=0$

What are the solutions to the equation above?
A. $a=1$
B. $a=\frac{4}{3}$
C. $\mathrm{a}=1$ and $\mathrm{a}=\frac{4}{3}$
D. $a=0$ and $a=-\frac{1}{3}$

Correct answer: C difficult degree: 3
25. $k\left(k-\frac{1}{2}\right)=-\frac{1}{16}$

What are the solutions to the equation above?
A. $\mathrm{k}=\frac{1}{8}$
B. $\mathrm{k}=\frac{1}{4}$
C. $k=-\frac{1}{8}$ and $k=\frac{1}{8}$
D. $k=-\frac{1}{4}$ and $k=\frac{1}{4}$

Correct answer: B difficult degree: 3
26. $\left(t+\frac{8}{3}\right)(t+b)=0$

In the equation above, $b$ is a constant. If $-\frac{8}{3}$ and $\frac{13}{3}$ are solutions to the equation, then what is the value of $b$ ?
A. $-\frac{13}{3}$
B. $-\frac{8}{3}$
C. $\frac{8}{3}$
D. $\frac{13}{3}$

Correct answer: A difficult degree: 4
27. $\left(v+\frac{1}{5}\right)^{2}-9=0$

What is the sum of the solutions to the equation above?
A. $-\frac{3}{5}$
B. $-\frac{2}{5}$
C. $-\frac{1}{5}$
D. 0

Correct answer: B difficult degree: 4
28. $(x-a)^{2}-3=0$

In the equation above, $a$ is a constant. If the equation has the solutions $x=4 \pm \sqrt{ } 3$, what is the value of $a$ ?

Correct answer: 4 difficult degree: 4
29. $(x+1) c+x^{2}=0$

In the equation above, $c$ is a constant.
The equation has solutions at $-\frac{3}{2}$ and -3 . What is the value of $c$ ?
A. $\frac{3}{2}$
B. 3
C. $\frac{9}{2}$
D. 9

Correct answer: C difficult degree: 4
30. $2(x-3)^{2}-b=0$

In the equation above, $b$ is a constant. If the equation has the solutions $x=3 \pm \sqrt{ } 5$, what is the value of $b$ ?
31. $-\left(\frac{12}{8}-b\right)=-b^{2}$

If $\mathrm{b}=\mathrm{s}$ and $\mathrm{b}=t$ are the solutions to the equation above, what is the value of $s t$ ?
A. $-\frac{3}{2}$
B. $-\frac{2}{3}$
C. $\frac{2}{3}$
D. $\frac{3}{2}$

Correct answer: A difficult degree: 4
32. $3 x^{2}+4 x-k=0$

In the equation above, $k$ is a constant. For what value of $k$ does the equation have no real solutions?
A. $-\frac{4}{3}$
B. $\frac{4}{3}$
C. $-\frac{5}{3}$
D. $\frac{5}{3}$

Correct answer: C difficult degree: 4
33. $\frac{1}{2} x^{2}-\frac{1}{6} x-\frac{1}{3}=0$

What are the solutions to the equation above?
A. $x=1$ and $x=-\frac{2}{3}$
B. $x=\frac{1}{6}-\sqrt{\frac{23}{36}}$ and $x=\frac{1}{6}+\sqrt{\frac{23}{36}}$
C. $x=2$ and $x=-\frac{4}{3}$
D. $x=\frac{1}{6}-\sqrt{-\frac{23}{36}}$ and $x=\frac{1}{6}+\sqrt{-\frac{23}{36}}$

Correct answer: A difficult degree: 4
34. $(t+1)^{2}+c=0$

In the equation above, $c$ is a constant.
The equation has solutions at $t=\frac{3}{2}$ and $t=-\frac{7}{2}$. What is the value of $c$ ?
A. $-\frac{729}{4}$
B. $-\frac{121}{4}$
C. $-\frac{25}{4}$
D. -1

Correct answer: C difficult degree: 4
35. $x^{2}+k x-14=0$

In the equation above, $k$ is a constant. The equation has solutions at 7 and -2 . What is the value of $k$ ?
A. -9
B. -5
C. 5
D. 9

Correct answer: B difficult degree: 4
36. $a t^{2}+\frac{7}{2} t-4=0$

The above equation has solutions at $t=-8$ and $t=1$. What is the value of the constant $a$ ?

Correct answer: $1 / 2$ difficult degree: 4
37. $4+k p=4 p^{2}$

In the equation above, $k$ is a constant. If the sum of the solutions to the equation is 0 , what is the value of $k$ ?
A. 0
B. 1
C. 2
D. 4

Correct answer: A difficult degree: 4
38. $16 x^{2}-8 x-3=0$

Let $x=q$ and $x=r$ be solutions to the equation shown above, with $q>r$. What is the
value of $q-r$ ?
Correct answer: 1 difficult degree: 4

## Interpreting nonlinear expressions

1. Ben Frank is an electrician who installs lighting fixtures. He charges (in dollars) his clients $15 h+40 f$ where $h$ is the number of hours worked and $f$ is the number of fixtures installed.

How much does Ben Frank charge when he works 7 hours and installs 9 fixtures?
Correct answer: \$465 level:1
2. The expression for the surface area of a cube of side length $s$ is $6 s^{2}$.

What is the surface area of a cube with side length $\frac{3}{2}$ units?
Correct answer: $27 / 2$ square units level:1
3. Eric owns and operates the Hot Ham food truck. The expression $3.25 b+2 h$ gives the cost $b$ burgers and $h$ hot dogs.

What is the cost of 4 burgers and 6 hot dogs?
Correct answer: $\$ 25$ level:1
4. The expression $12 g$ gives the number of kilometers a car can travel using $g$ liters of gasoline.

How far can this car travel on $5 \frac{1}{2}$ liters of gasoline?
Correct answer: 66 km level:1
5. The price of a visit to the dentist is calculated according to the formula $50+100 n$ where $n$ is the number of cavities the dentist finds.

On your last visit to the dentist, 2 cavities were found.
What was the cost of your visit?

Correct answer: $\$ 250$ level:1
6. $\operatorname{shc}(q)=2 q+155 \sqrt{q}+2,000$

A company manufactures bookcases. The function above gives the cost, $C(q)$, in dollars, of producing $q$ bookcases. What is the fixed cost of production before any bookcases are produced?

Correct answer: 2000 level:2
7. The following equation shows the height, $h$, in meters above the ground of a football $t$ seconds after a particular kick.

$$
h=0.3+5.5 t-4.9 t^{2}
$$

What was the height of the football at the moment of the kick?
Correct answer: 0.3 meters level:2
8. $B(n)=2^{n}$

A binary code word of length $n$ is a string of 0 's and 1's with $n$ digits. For example, 1001 is a binary code word of length 4 . The number of binary code words, $B(n)$, of length $n$, is shown above. If the length is increased from $n$ to $n+1$, how many more binary code words will there be?
A. 2
B. $2^{n}$
C. $2^{n+1}$
D. $4^{n}$

Correct answer: B level: 2
9. $F(t)=1,500(1.045)^{t}$

The future value, $F(t)$, of an investment after $t$ years is given by the function defined above. What is the initial value of the investment?

Correct answer: 1500 level: 2
10. $R(q)=-0.31(q-260)^{2}+18,500$

A shoe manufacturer determines that its monthly revenue, $R(q)$, in dollars, is given by the function defined above, where $q$ is the number of pairs of shoes sold each month. What is the maximum value of the company's monthly revenue?

Correct answer: 18500 level: 2
11. $P=\$ 150\left(\frac{1-\left(\frac{1}{1.03}\right)^{10}}{0.03}\right)$

The equation above gives the present value, $P$, of an investment that pays the investor $\$ 150$ per year for 1010 years. The present value is the dollar amount that is equal to the series of future payments. If the payments are changed from $\$ 150$ to $\$ 75$, what is the effect on the present value $P$ ?
A. the present value stays the same
B. the present value is halved
C. the present value doubles
D. the present value increases by $3 \%$

Correct Answer: B level: 2
12. $P(q)=-0.01(q-250)(q-80)$

The equation above gives the profit, $P(q)$, in dollars, earned by a cupcake bakery when $q$ cupcakes are produced. What is the best interpretation of the number 8080 in this context?
A. 80 is a number of cupcakes for which the profit is equal to $\$ 0$.
B. 80 is the number of cupcakes that corresponds to the maximu profit.
C. 80 is the number of cupcakes that corresponds to the minimum profit.
D. $\$ 80$ is the maximum profit, in dollars.

Correct Answer: A level: 2
13. $m=0.031 x^{2}-0.09 x+181.5$

Mehmet experimented with the number of grams (g) of sugar that would dissolve in a specific volume of water at different temperatures. He modeled his results using the above equation to represent the number of grams, $m$, of sugar that dissolved when the water was $x$ degrees Celsius $\left({ }^{\circ} \mathrm{C}\right)$. What is the best interpretation of the 181.5 in Mehmet's equation?
A. In his experiment, a maximum of 181.5 g of sugar dissolved in the water.
B. In his experiment, 0 g of sugar dissolved when the water temperature was 181.5 ${ }^{\circ} \mathrm{C}$.
C. In his experiment, when the water temperature was $0^{\circ} \mathrm{C}, 181.5 \mathrm{~g}$ of sugar dissolved.
D. In his experiment, the maximum number of grams of sugar dissolved when the water temperature was $181.5^{\circ} \mathrm{C}$.
Correct Answer: C level: 2
14. $T(r)=\frac{72}{r}$

The Rule of 72 estimates the time, $T(r)$, in years, needed for an investment to double when the annual interest rate is $r \%$, as shown in the function above. Which of the following is the best description of the number 72 in this context?
A. 72 is the time needed for any investment to double.
B. 72 is the number of years needed for an investment to double when the annual interest rate is $1 \%$.
C. 72 is the maximum number of years it can take for an investment to double.
D. 72 is the number of years needed for an investment to double when the annual interest rate is $2 \%$. Correct Answer: B level: 3
15. $A(x)=-\frac{1}{4}(x-25)^{2}+625$

The area, $A(x)$, of a rectangular enclosure that can be made from a limited amount of fencing is shown above, where $x$ is the length of one of the sides of the enclosure, measured in feet. What is the maximum area that can be enclosed?

Correct Answer: 625 sq ft level: 3
16. Wilma created the following formula to model the distance, $d$, in inches above the floor of her jump after $t$ seconds had passed.
$d=144 t(0.5-t)$
What is the best interpretation of the number 0.5 in this equation?
A. Wilma jumped from an initial height of 0.5 inches.
B. Wilma landed on the ground 0.5 seconds after she jumped.
C. Wilma jumped with an initial velocity of 0.5 inches per second.
D. Wilma's jump reached a maximum distance of 0.5 inches above the floor. Correct Answer: B level: 3
17. $P(t)=25(2)^{\frac{t}{1.06}}$

The number of yeast cells, $P(t)$, in a culture after $t$ days is modeled by the equation shown above. After how many days will the population double in size? Round the answer to the nearest tenth.

Correct Answer: 1.1 level: 3
18. The equation below models the height, $h$, in feet above the water for a cable in a suspension bridge at a horizontal distance, $x$, in feet from the beginning of the span.
$h=0.0002(x-1,955)^{2}+100$
How many feet above the water is the lowest point on the cable?
Correct Answer: 100 feet level: 3
19. $P(s)=-(s-a)^{2}+b$

The Yerkes-Dodson law predicts that the relationship between stress level, $s$, and performance, $P(s)$, of a difficult task can be modeled by a function of the form shown above, where $a$ and $b$ are constants related to the measures of stress and performance for a particular task. What is the best interpretation of $a$ in this context?
A. $a$ is the level of stress at which performance is minimal.
B. $a$ is the level of peak performance.
C. $a$ is the level of stress at which performance is maximal.
D. $a$ is the level of stress at which performance is $\frac{1}{2}$ of maximal performance.

```
Correct Answer: C level: 3
```

20. $F(t)=(0.95)^{\frac{t}{2}}$

The function $F(t)$ defined above gives the percentage of information Dianna retained $t$ days after memorizing lines for a play. Assuming she did not work on her lines again, what is the best description of 0.95 in this context?
A. Dianna will forget $95 \%$ of what she retained one day ago.
B. Dianna will forget $95 \%$ of what she retained two days ago.
C. Dianna will remember $95 \%$ of what she retained one day ago.
D. Dianna will remember $95 \%$ of what she retained two days ago.

Correct Answer: D level: 4
21. The amount of water vapor, $v$ (in grams), that will saturate 1 kilogram of dry air when the temperature is $d$ degrees Celsius is approximated by the following equation.
$v=4.041 .07^{x}$
For each increase of 1 degree, what is the percent increase in the amount of water vapor required to saturate the air according to this model?
(Do not type the percent sign.)
Correct Answer: $7 \%$ level: 4
22. The administrators of a factory modeled the cumulative average construction time in minutes per engine component as a function of the total number of components their employees had constructed, $n$, using the following function:
$T(n)=3.5+7 \quad 0.9^{n}$
What was the cumulative average time for an employee to construct one engine component when they first began?

Correct Answer: 10.5 minutes per engine component level: 4
23. $r=0.5(1.2)^{\vartheta}$

A certain type of mollusk has a shell in the shape of a spiral, as shown below. The distance, $r$, from the origin to a point on the spiral is modeled by the equation above, where $\vartheta$ is the angle, in radians, measured counterclockwise from the positive $x x$-axis to the same point on the spiral. What is the best description of 0.5 in this formula?

A. 0.5 is the rate of increase of the radius per $2 \pi$ radians.
B. 0.5 is the ratio of radii that differ by $2 \pi$ radians.
C. 0.5 units is the length of the radius corresponding to $\vartheta=0$.
D. 0.5 units is the length of the radius corresponding to $\vartheta=2 \pi$.

Correct Answer: C level: 4
24. According to Bernoulli's equation below, the product of the area, $A_{1}$, of a cross-section of a hose at a particular point and the velocity, $V_{1}$, of water traveling through the hose at that point will be equal to the product of the area, $A_{2}$, of a second cross-section of the same hose at a second point and the velocity,
$V_{2}$, of water traveling through the hose at the second point.
$A_{1} V_{1}=A_{2} V_{2}$
If someone covers $\frac{1}{4}$ of the opening of a hose, how will the velocity of the water coming out of the hose change?
A. The velocity of the water through the partially covered opening will be $\frac{1}{4}$ of the velocity through the full opening.
B. The velocity of the water through the partially covered opening will be $\frac{3}{4}$ of the velocity through the full opening.
C. The velocity of the water through the partially covered opening will be $\frac{4}{3}$ of the velocity through the full opening.
D. The velocity of the water through the partially covered opening will be 4 times the velocity through the full opening. Correct Answer: C level: 4
25. $P(t)=400(1.5)^{t}$

Biologists stocked a lake with a new species of fish. The number of the new species of fish in the lake, $P(t), t$ years after being stocked, is shown above. How many fish did the biologists initially add to the lake?

Correct Answer: 400 level: 4
26. $A(x)=\frac{20,000+0.15 \mathrm{x}}{x}$

A doughnut franchise has determined that its average cost per unit (doughnut), $A(x)$, is given by the above function, where $x$ is the number of units produced, $x>0$. Which of the following best describes what happens to the average cost per doughnut as the number of doughnuts produced increases?
A. The average cost gets closer and closer to 0 .
B. The average cost gets closer and closer to $\$ 0.15$ per doughnut.
C. The average cost is $\$ 0.15$ per doughnut.
D. The average cost gets closer and closer to $\$ 20,000$ per doughnut.

Correct Answer: B level: 4
27. Reem is a test driver for an automobile company. The following formula gives the total distance,d, in feet that Reem drove a luxury car in the first $t$ seconds after idling at a speed of 0 miles per hour, up to the time when she passed a particular safety cone.
$d=15.69 t^{2}$
Compared to the time it took Reem to pass the safety cone, how long did it take to pass a sensor that was $\frac{4}{9}$ of the distance from the start?
A. $\frac{16}{81}$ of the time it required to pass the cone
B. $\frac{4}{9}$ of the time it required to pass the cone
C. $\frac{2}{3}$ of the time it required to pass the cone
D. $\frac{9}{4}$ of the time it required to pass the cone Correct Answer: C level: 4
28. The temperature $T$ in degrees Celsius of a chilled drink after mm minutes sitting on a table is given by the following function.
$T(m)=32-28 \quad 3^{-0.05 m}$
What is the best interpretation of the number 32 in this function?
A. The drink is originally 32 degrees Celsius.
B. Every 32 minutes, the temperature warms by 3 degrees Celsius.
C. After 32 minutes, the drink will fully warm to the ambient temperature.
D. After sitting for a very long time, the drink will warm up to 32 degrees Celsius.

Correct Answer: D level: 4

## Quadratic and exponential word problems

1. $s(s-1)=2$

What are the solutions to the equation above?
A. $s=-2$ and $s=1$
B. $s=0$ and $s=-1$
C. $s=0$ and $s=1$
D. $s=2$ and $s=-1$

Correct answer: A

## level: 1

2. $x^{2}-10 x+21=0$

Let $x=h$ and $x=m$ be solutions to the equation above, with $h>m$. What is the value of $h-m$ ?

Correct answer: 4 level: 1
3. $6 x^{2}-7 x-5=0$

Let $x=j$ and $x=k$ be solutions to the equation above, with $j>k$. What is the value of $j-k$ ?

Correct answer: 13/6 level: 1
4. $x^{2}+\frac{13}{2} x+\frac{15}{2}=0$

If $x=a$ and $x=b$ are the solutions to the equation above, what is the value of $a b$ ?
A. -15
B. $-\frac{15}{2}$
C. $\frac{15}{2}$
D. 15

Correct answer: C level: 1
5. $1,000=20 z^{2}$

How many distinct real solutions does the equation above have?
A. 0
B. 1
C. 2
D. 4

Correct answer: C level: 1
6. A factory designs cylindrical cans 10 cm in height to hold exactly $500 \mathrm{~cm}^{3}$ of liquid. Which of the following best approximates the radius of these cans?
A. 4 cm
B. 8 cm
C. 12.5 cm
D. 15.9 cm

Correct answer: A level: 2
7. A minor league hockey team has been collecting ticket sales data over the past year. At a current price of $\$ 25$ per ticket, an average of 4000 seats are purchased. They predict that for each $\$ 1$ increase in ticket price, 100 fewer tickets will be sold. Which of the following functions best models the amount of money that the hockey teams expect to collect from ticket sales, $y$, based on an $\$ x$ increase in ticket price?
A. $y=(25+x)(4000-100 x)$
B. $y=(25-x)(4000+100 x)$
C. $y=x(4000-100 x)$
D. $y=4000(25+x)$

Correct answer: A
level: 2
8. Rajeev has $\$ 175$ that he earned from his summer job. He puts the money in an account that yields $4 \%$ interest compounded annually. Assume that Rajeev does not make any other deposits or withdrawals from his account. After how many years from the time he deposited the money will Rajeev have at least $\$ 200$ in his account?
A. 1 year
B. 2 years
C. 3 years
D. 4 years

Correct answer: D level: 2
9. Lamian is a Chinese noodle made by repeatedly folding and stretching dough to make noodles of varying thickness. A ball of dough is rolled into a long "rope" 2 centimeters ( cm ) in diameter. One end of the dough is held in each hand, and the dough is stretched and folded, making 2 separate strands. This process is repeated until the strands are the desired thickness.
Assume that each time the dough is stretched, the thickness of each noodle decreases by $30 \%$. How many folds will be needed to produce noodles whose thickness is at most 0.5 cm ?
A. 2
B. 3
C. 4
D. 5

Correct answer: C level: 2
10. $p=\frac{1}{2} k x^{2}$

The seat on a tractor is mounted on springs in order to absorb impact. The driver sits on the seat, and the springs compress a distance of $x$ meters. As the springs compress, potential energy, $p$, in joules, is stored in them according to the equation above. The spring constant, $k$, describes the strength of the springs in newtons per meter. If the springs have a spring constant of 25,600 newtons per meter, how much must the strings stretch, in meters, in order to store 88 joules of potential energy?
A. 0.000625 meters
B. 0.025 meters
C. 3200 meters
D. 102,400 meters

Correct answer: B level: 2
11. The present value, ( $P V$ ), of an investment is the amount that should be invested today at a specified interest rate in order to earn a certain amount at a future date. The amount desired is called the future value. Approximately how much should be invested today in a savings account that earns $3 \%$ interest compounded annually in order to have $\$ 500$ in 2 years?
A. $\$ 515$
B. $\$ 470$
C. $\$ 485$
D. $\$ 530$

Correct answer: B level: 2
12. $I=870 \pi^{2} a^{2} f^{2}$

The intensity, $l$, of a sound wave is defined as its power output per unit area and is measured in watts per square meter $\left(\frac{W}{m^{2}}\right)$. A sound wave's intensity can be calculated using the above equation, where aa stands for the wave's amplitude in meters $(\mathrm{m})$ and $f$ stands for its frequency of vibration in hertz $(\mathrm{Hz})$. If a particular sound wave has an intensity of $0.05 \frac{\mathrm{~W}}{\mathrm{~m}^{2}}$ and an amplitude of $3 \times 10^{-5} \mathrm{~m}$, which of the following is most nearly its frequency?
A. 8.77 hertz
B. 80 hertz
C. 6,500 hertz
D. $4 \times 10^{7}$ hertz

Correct answer: B level: 2
13. A cable company with a reputation for poor customer service is losing subscribers at a rate of approximately $3 \%$ per year. The company had 2 million subscribers at the start of 2014.
Assume that the company continues to lose subscribers at the same rate, and that there are no new subscribers. Which of the following functions, $S$, models the number of subscribers (in millions) remaining $t$ years after the start of 2014?
A. $S(t)=2(1.03)^{t}$
B. $S(t)=2(0.97)^{t}$
C. $S(t)=2(0.70)^{t}$
D. $S(t)=2(0.97) t$

Correct answer: B level: 2

## Water Level vs. Time

Time (s) Height ( cm )
$5 \quad 50.5$
$10 \quad 42.0$
$40 \quad 12.0$
14. A teacher fills a 5 gallon bucket with water, punches a small hole near the bottom, and asks his students to make measurements as the water drains. Next, the teacher asks the
students to fit their data to a quadratic function of the form $h(t)=60-b t+c t^{2}$. The table at the left represents the students' measurement of the height of the water in the bucket, in centimeters (cm), $t$ seconds (s) after it begins draining. Which of the following is most nearly the height expected after 30s?
A. 18 centimeters
B. 42 centimeters
C. 60 centimeters
D. 138 centimeters

Correct answer: A
level: 2
15. The number of secure Internet servers in the United States from 2009 to 2013 can be modeled by a quadratic function. The graph below approximates the number of secure internet servers, $s$, per 1 million people, for a given year, where $t$ represents the years since 2009. Which of the following functions best models the number of secure Internet servers in the United States per 1 million people between 2009 and 2013?
A. $s=-7(t+2)^{2}-1560$
B. $s=-7(t-2)^{2}+1560$
C. $s=-64(t+2)^{2}-1560$
D. $s=-64(t-2)^{2}+1560$


Correct answer: D
level: 2
16. Emma would like to determine how much time she should spend studying tonight for her math test tomorrow. If she studies too little, she will not know the material and as a result get a poor grade. Too much studying will cut into her sleep and may also prove detrimental. She makes a sketch to model what she predicts her grade will be, $g$, based on the hours she spends studying the night before, $h$. Assuming that the graph below shows a quadratic relationship, which of the following functions best approximates the relationship between the hours Emma spends studying and her test grade for $0 \leq h \leq 4$ ?
A. $g=-11.5(h+2)^{2}+96$
B. $g=-11.5(h-2)^{2}+96$
C. $g=-36.5(h+2)^{2}-96$
D. $g=-36.5(h-2)^{2}-96$


Correct answer: B level: 2
17. In the year 1859, 24 rabbits were brought from Europe to Australia, where they were released into the wild. By 1920, there were 10 billion rabbits in Australia. Which of the following functions, $R$, could model the rabbit population of Australia $t$ years after 1859?
A. $R(t)=24+(1.3845) t$
B. $R(t)=24(1.3845)^{t}$
C. $R(t)=24(0.6155)^{t}$
D. $R(t)=10^{10}(1.3845)^{t}$

Correct answer: B level: 2
18. Tritium, a radioactive isotope of hydrogen, is often used in emergency EXIT signs. Because of the radioactive substance present in these signs, proper disposal is a matter of concern to the Environmental Protection Agency. The half-life of tritium is approximately 12 years. That is, every 12 years, the amount of tritium decreases by $50 \%$. If a new tritium EXIT sign contains 25 curies of tritium, approximately how many curies of tritium will remain after 24 years?
A. 6.25 curies
B. 12.5 curies
C. 25 curies
D. 30 curies

Correct answer: A
level: 2
19. Zayed plans to double the area of his rectangular garage by adding 2 ft to its original width, $w$, and 8 ft to its original length, $l$, where $w$ and $/$ are measured in ft . If the original area of the garage is $120 \mathrm{ft}^{2}$, which of the following equations could be used to find the original width of the garage?
A. $(w+2)\left(\frac{120}{w}+8\right)=120$
B. $(w+2)\left(\frac{120}{w}+8\right)=240$
C. $(w+2)(128-w)=120$
D. $(w+2)(128-w)=240$

Correct answer: B level: 2
20. Poultry should be cooked to a temperature of $75^{\circ} \mathrm{C}$. A chicken is removed from the oven and left to rest in a room that is at a constant temperature of $22^{\circ} \mathrm{C}$. The temperature of the chicken $t$ hours after it is removed from the oven is given by the exponential function:
$T(t)=22+53(0.74)^{t}$
What is the approximate temperature of the chicken after 22 hours?
A. $22^{\circ} \mathrm{C}$
B. $51^{\circ} \mathrm{C}$
C. $74^{\circ} \mathrm{C}$
D. $75^{\circ} \mathrm{C}$

Correct answer: B level: 2
21. The fuel economy of a vehicle, in miles per gallon $\left(\frac{m i}{g a l}\right)$, can be modeled by a quadratic function of the vehicle's speed. A team of engineers is testing a new vehicle for fuel economy and finds that its maximum fuel economy of $30 \frac{\mathrm{mi}}{\mathrm{gal}}$ is achieved at a speed of 48 miles per hour ( $\frac{m i}{h r}$ ). In high speed tests, the fuel economy is found to be $14 \frac{m i}{g a l}$ at a speed of $88 \frac{m i}{h r}$. What is the expected fuel economy at a speed of $58 \frac{m i}{h r}$ ?
A. 29 miles per gallon
B. 29.9 miles per gallon
C. 30.1 miles per gallon
D. 31 miles per gallon Correct answer: A level: 3
22. A physical education teacher is planning to outline two adjacent identical rectangular areas for a new game that students will be learning. If the boundaries of this "court" must be marked with a 5050 yard roll of tape, what is the maximum area of one of the smaller rectangular spaces in square yards?
court


Correct answer: $52 \pm 0.5$ level: 3
23. Over the course of a year, from April to the following March, a business owner sees a rise and fall in her monthly profits, which can be approximated by a quadratic function. A maximum profit of $\$ 12,000$ is recorded during the month of September. By January, that figure has dropped to $\$ 4,000$. According to these numbers, approximately how much profit, in dollars, did the business owner record during February of that year? Note, negative profit just indicates a loss.
A. $-\$ 12,500$
B. $-\$ 500$
C. \$500
D. $\$ 12,500$

Correct answer: B level: 3
24. Akoni, a painter, painted a circular helicopter landing pad one color. Next she painted over a 3meter radius circle in the center, in a different color. If the second coat of paint covered an area half the size of the first coat, which of the following is most nearly the radius of the landing pad?
A. 2 meters
B. 3 meters
C. 4 meters
D. 6 meters

Correct answer: C level: 3
25. The width of a rectangular box is 2 cm less than its length. The height of the box is 8 cm . Which of the following functions represents the surface area, $S$, in square centimeters, of the box with side length $x$ ?
A. $S=x^{2}+14 x-16$
B. $S=2 x^{2}+28 x-32$
C. $S=16+2 x-x^{2}$
D. $S=32+4 x-2 x^{2}$

Correct answer: B level: 3
26.

## Potato Height vs. Time

| Time (in seconds) | Height (in feet) |
| :---: | :---: |
| 0.35 | 2.04 |
| $?$ | 1.44 |
| 0.50 | 0 |

Yusef is designing a system to load potatoes onto trucks at a potato farm. The potatoes have an initial vertical speed of $v$ feet per second and a starting height of $h_{0}$ feet. During a fall of $t$ seconds, the potatoes' heights can be modeled by a quadratic function of the form $h(t)=h_{0}-v t-16 t^{2}$. The data in the table above shows the height of a potato after $t$ seconds of free fall. How many seconds does it take for a potato to drop to a height of 1.44 feet?

Correct answer: 0.4 level: 3
27. A rocket is moving upward when its fuel runs out. The rocket enters into freefall, continuing to move with an upward velocity at first. The rocket's height, $h$, in feet, $t$ seconds after running out of fuel can be modeled by a quadratic function of the form $h(t)=-16 t^{2}+b t+c$. This particular rocket has a height of 356 when the fuel runs out. It then reaches a height of 550 feet 2 seconds later. What is the rocket's height, in feet, 10 seconds after the fuel runs out?

Correct answer: 46 level: 3
28.

## Useful square root values

| $x$ | $\sqrt{x}$ |
| :--- | :--- |
| 1 | 1 |
| 2 | $1.414 \ldots$ |
| 3 | $1.732 \ldots$ |
| 4 | 2 |
| 5 | $2.236 \ldots$ |
| $x^{2}-x-1=0$ |  |

The golden ratio is a controversial number believed by many to describe various natural structures such as vein and stem structures in plants and even DNA. It is often expressed as the positive solution to the above quadratic equation. Rounded to the nearest hundredth, what is the golden ratio expressed as a decimal?

Correct answer: 1.62 level: 3
29.

Last Month Profit vs. Spending
Advertising Spending (in hundreds of \$) Profit (in hundreds of \$)

10450
40
240

For a particular company, the data in the table above shows the profit, $P$, corresponding to xxhundred dollars spent on advertising last month. It is determined that the profit can be modeled by a quadratic function of the form $P(x)=c+b x-0.5 x^{2}$. If 20 hundreds of dollars is spent on advertising, how much profit is expected to be made, in hundreds of dollars?

Correct answer:
30. A real estate purveyor purchases a 60,000 square foot $\left(\mathrm{ft}^{2}\right)$ warehouse and decides to turn it into a storage facility. The warehouse's width is exactly $\frac{2}{3}$ of its length. What is the warehouse's width? Round your answer to the nearest foot.

Correct answer: 200 level: 3
31.

Drag Force vs. Speed

| Speed $\left(\right.$ in $\left.\frac{\mathrm{m}}{\mathrm{s}}\right)$ | Drag Force $($ in N$)$ |
| :---: | :---: |
| 8 | 720 |
| 10 | 1100 |

A design engineer is measuring the drag force (i.e. the force resisting motion) on a robotic submarine. As the submarine moves through the water at $v$ meters per second $\left(\frac{m}{s}\right)$, it experiences a drag force of $F$ newtons ( $N$ ). The table above represents the design engineer's measurements. If the drag force can be modeled by a quadratic equation of the form $F=b v+c v^{2}$, what value of speed, in meters per second, corresponds a drag force of 120 N ? Round your answer to the nearest tenth of a meter per second.

Correct answer: 3 level: 3
32. Hung Lam plans to enclose a rectangular area for his chickens in his backyard using the sides of his apartment building for 2 of the sides, as seen in the figure at left. If Hung Lam has exactly 40 feet of chicken wire, what is the largest area, in square feet, he can enclose for his chickens?


Correct answer
level: 3
33.

Dart Speed vs. Penetration

| Speed $\left(\operatorname{in} \frac{\mathrm{m}}{\mathrm{s}}\right)$ | Penetration distance $(\mathrm{in} \mathrm{mm})$ |
| :---: | :---: |
| 5 | 11.5 |
| 7 | 18.7 |
| 9 | $[?]$ |

Billiards Rec., Inc. has developed a new foam to be used in dart boards and is testing its dart-stopping ability. The data in the table above shows the test darts' average penetration distance, $d$, in millimeters ( mm ), when thrown at a speed of approximately $v$ meters per second $\left(\frac{m}{s}\right)$. The stopping distance of the darts is a quadratic function of their speed and can be modeled by a function of the form $d=a v$ ${ }^{2}+c$. If a dart was thrown at a speed of $9 \frac{m}{s}$, which of the following best approximates the dart's penetration distance, in millimeters?
A. 0.3 millimeters
B. 4 millimeters
C. 25.9 millimeters
D. 28.3 millimeters

Correct answer: D level: 3
34.

| Rocket Height vs. Time |  |
| :---: | :---: |
| Time after takeoff $($ in s) | Height $($ in ft$)$ |
| 1 | 90 |
| 3 | 730 |

The above table gives a particular rocket's height, in feet ( ft ) above sea level, $t$ seconds after takeoff. The rocket's height can be modeled by a quadratic function of the form $h(t)=a t^{2}+c$. How many feet above sea level is the rocket 2 seconds after takeoff?

Correct answer:
level: 3
35. A helicopter hovers over a mountain top, and a professional snowboarder drops onto the snow 25 feet below. The snowboarder's height off the ground, in feet, while falling can be modeled by a quadratic function of seconds of falling, $t$,
which has the form $h(t)=d-a t^{2}$. If the snowboarder is still 21 feet above the ground after falling for 0.5 seconds, how long does the entire 25 foot drop take? Round your answer to the nearest hundredth of a second.

Correct answer: 1.25 level: 3
36. The length of an 8000 square foot rectangular gymnasium is 20 feet greater than its width. What is its width, in feet?

Correct answer: 80 level: 3
37. When a ball strikes a wall it spends a certain amount of time in contact with the wall before rebounding away. While in contact with the wall, the ball compresses, and the separation between the wall and the ball's center $t$ seconds after contacting the wall can be modeled by a quadratic function. The maximum separation, 0.0285 meters, occurs when the ball first contacts the wall. If the ball is only in contact with the wall for 0.06 seconds, and the minimum separation is 0.006 meters, which of the following functions best models the separation, $d$, between the wall and the ball's center?
A. $d(t)=25(t-0.03)^{2}+0.006$
B. $d(t)=25(t-0.06)^{2}+0.006$
C. $d(t)=0.0285(t-0.03)^{2}+0.006$
D. $d(t)=0.0285(t-0.06)^{2}+0.006$

Correct answer: A level: 3
38. Drake and Cleo are looking for a location to open their new yoga studio. A fellow studio owner suggests a location that will fit 28 students in a 756 square foot area. Assuming that each student has a spot $x$ feet wide and 3 times as long, what is the length, in feet, of the space they are allotting to each student?
A. 1 feet
B. 3 feet
C. 9 feet
D. 27 feet

Correct answer: C
level: 3
39. $V=A t$

A confectioner is applying a sugar coating to some spherical candies. The above equation gives a good approximation of the volume of coating, $V$, in cubic millimeters $\left(\mathrm{mm}^{3}\right)$, needed for a coating that is $t \mathrm{~mm}$ thick on a candy with a surface area of $A \mathrm{~mm}^{2}$. For a coating volume of $20 \pi \mathrm{~mm}^{3}$ and a coating thickness of 0.2 mm ,
which of the following best approximates the radius of these candies? Use $\pi \approx 3.14$, and round your answer to the nearest hundredth of a millimeter.
The surface area of a sphere can be calculated as $A=4 \pi r^{2}$.
Correct answer: 5 level:3
40.

## Size of solar PV industry each year

| Year | Size of solar PV industry each year <br> Size based on minimum <br> growth (in gigawatts) | Size based on maximum <br> growth (in gigawatts) |
| :---: | ---: | ---: |
| 2007 | 3.8 | 3.8 |
| 2008 | 5.4 | 5.7 |
| 2009 | 7.6 | 8.4 |
| 2010 | 10.7 | 12.4 |
| 2011 | 15.1 | 18.3 |
| 2012 | 21.2 | 27 |
| 2013 | 29.9 | 40 |
| 2014 | 42.2 | 59.2 |
| 2015 | 59.4 | 87.5 |
| 2016 | 83.8 | 129.5 |
| 2017 | 118.1 | 191.7 |
| 2018 | 166.5 | 283.6 |
| 2019 | 234.7 | 419.7 |
| 2020 | 330.9 | 621.2 |

The growth rate of the solar PV industry has consistently fallen between $41 \%$ and $48 \%$ every year since 2007. On the table at left, the size of the solar PV industry based on its minimum (41\%) and maximum (48\%) growth rate is shown. Which of the following estimates the size of the solar PV industry in 2022 based on the minimum growth rate?
A. 55 gigawatts
B. 340 gigawatts
C. 490 gigawatts
D. 660 gigawatts

Correct answer: D
41. A biologist puts a certain number of DNA strands into a machine, which uses a process called PCR cycling. Each PCR cycle, the machine creates a copy of every DNA strand. All of the DNA strands (the original DNA strands and their copies) remain together in the machine, ready for more PCR cycles. If a biologist puts 1 thousand DNA strands into the machine and runs it for 44cycles, how many DNA strands will be in the machine at the end of the process, in thousands?

Correct answer:
42.

Evolutionary medicine publications each year
Number of publications Year
512000
632001
$79 \quad 2002$
$99 \quad 2003$
1242004
1562005
1952006
$244 \quad 2007$
3062008
$383 \quad 2009$

The number of medical publications that mention evolutionary medicine each year is shown at left, with the data for 2010 and 2011 missing. Based on the entire trend of the data, how many publications mentioned evolutionary medicine in 2011?
A. 70
B. 160
C. 480
D. 530

Correct answer: D level: 3
43. Average number of transistors on computer chip each year

| Year | Transistor count (in millions) |
| :--- | :--- |
| 1970 | 0.046 |
| 1980 | 0.099 |
| 1990 | 0.215 |
| 2000 | 0.466 |
| 2010 | 1.009 |

The number of transistors on an average computer chip has increased exponentially over time, as shown above. Assuming this pattern will continue until the number of transistors on a computer chip reaches 10 million, in what year will that chip be produced, to the nearest 10 years?

Correct answer: 2040 level: 3
44. In the following list of equations, the numbers on the left are written using the base 5 number system, and, therefore, are denoted with a subscript of 5 . The numbers on the right are written in our normal base 10 number system. For example, the base 5 number 100 is equal to the base 10 number 25 .

$$
1_{5}=1
$$

$$
10_{5}=5
$$

$$
100_{5}=25
$$

$$
1,000_{5}=125
$$

$$
10,000_{5}=625
$$

If $10,000,000,000,000,000,000,000_{5}=5^{p}$, then what is the value of $p$ ?
Correct answer: 22 level:3
45.

Cost for computer memory each year
c $y$

901985
$20 \quad 1988$
11994
The table above shows how the cost, $c$, in dollars per megabyte, for computer memory decreased as the year, $y$, increased. If we expect the cost for computer memory to continue decreasing steadily, which of the following equations best models the relationship?
A. $c=-0.4 \cdot(y-2000)^{2}$
B. $c=0.4 \cdot(y-2000)^{2}$
C. $c=90 \cdot 0.61^{(y-1985)}$
D. $c=90 \cdot 1.61^{(y-1985)}$

Correct answer: C level: 3
46. The amount of methane, $p$, in parts per billion, in the atmosphere from 1760 to 2000, relative to the year, $y$, can be modeled by an exponential curve of the form $p=740+a^{(y-1760)}$, where $a$ is a constant. The amount of methane did not reach 800 parts per billion until about 1890, but then went all the way up to 1800 parts per billion around 1980 . Which of the following could be the value of $a$ ?
A. 0.032
B. 1.032
C. 2.032
D. 3.032

Correct answer: B level: 3
47. At a party, there is a cake of length $c$, as shown below. Each person at the party takes a slice of cake which is exactly half the length of whatever cake is remaining. Once people have taken $s$ slices, $a(s)$ represents the total length of cake taken. Which of the following equations computes $a(s)$ given $s$ ?

A. $a(s)=c\left[1-\left(\frac{1}{2}\right)^{s}\right]$
B. $a(s)=c\left[1-\left(\frac{1}{s}\right)^{2}\right]$
C. $a(s)=c\left(\frac{1}{2}\right)^{s}$
D. $a(s)=c\left(\frac{1}{s}\right)^{2}$

Correct answer: A
level: 3
48. Miguel numbers the 50 keys on his musical keyboard from left to right, starting at 0 . Miguel then uses an oscilloscope to measure the frequency, $f$, in Hertz, of the sound waves emitted when key number $k$ is pressed. The table below shows the measured frequency of some of the keys. Which of the following equations best models the relationship between the key number and the key frequency?

## Key number and frequency

| $k$ | $f$ |
| ---: | ---: |
| 0 | 65.5 |
| 12 | 131.0 |
| 24 | 262.0 |
| 36 | 524.0 |
| 48 | $1,048.0$ |

A. $f=65.52^{k}$
B. $f=65.52^{\frac{k}{12}}$
C. $f=65.5(k+1)$
D. $f=65.5+\left(\frac{k}{12}\right)$

Correct answer: B level: 3
49. The amount of carbon-14 in a sample decreases once the organism from which it came is no longer alive. A sample of an ancient fern fossil contains $42 \%$ of the amount of carbon-14 in living ferns. The fraction of carbon-14, $F$, left in the fossil sample $t$ years after it died can be modeled by the following function:
$F(t)=2^{-\frac{t}{5730}}$
Approximately how old is the fern fossil?
A. 4,000 years
B. 5,000 years
C. 7,000 years
D. 10,000 years Correct answer: C level: 4
50. An investment lost approximately $5 \%$ of the balance each month for the past year. The amount of the investment on January $1^{\text {st }}$ of last year was $\$ 10,000$. Which of the following functions, $I$, models the amount of the investment (in thousands of dollars) at the end of month, $n$, where $1 \leq n \leq 12$ ?
A. $I(n)=10 \cdot(1.05)^{n}$ thousand dollars
B. $I(n)=10-0.05 n$ thousand dollars
C. $I(n)=10 \cdot(0.95)^{n}$ thousand dollars
D. $I(n)=10+0.95 n$ thousand dollars

Correct answer: C level: 4
51. Kudzu is a vine that was introduced to the United States from Japan in 1876 as an ornamental plant. Starting in the year 1935, kudzu was planted throughout the Southeast to combat soil erosion. By 1946, kudzu covered approximately 3 million acres of land in the Southeast. Sixty years later, about 7 million acres were covered by kudzu. Which of the following functions best models the amount of kudzu, in millions of acres, $t$ years after 1946?
A. $K(t)=3 \cdot(1.014)^{t}$
B. $K(t)=3 \cdot(0.014)^{t}$
C. $K(t)=3+(1.014) t$
D. $K(t)=3+(0.014) t$

Correct answer: A level: 4
52. Caleb plans to install a patio of uniform width around a rectangular 15 ft by 30 ft pool in his back yard. If Caleb would like the total area of the pool and the patio to be approximately $800 \mathrm{ft}^{2}$, what should the approximate width of the patio be?
A. 3.4 feet
B. 5 feet
C. 6.7 feet
D. 18.4 feet

Correct answer: A
level: 4
53. If 2 people in a group of 30 have two-way radios, 1 connection can be made. If 3 people in that same group have two-way radios, 3 connections can be made. In fact, the number of connections that are possible, $C$, based on
having $x$ two-way radios in a group of 30 can be modeled by a quadratic function of the form $C=a x^{2}+b x$. Which of the following represents the number of connections that can be made if 6 people in this group have two-way radios?
A. 6
B. 9
C. 15
D. 18

Correct answer: C level: 4
54. Currently, a local newspaper company sells print subscriptions for $\$ 9.30$ a month and has 2400 subscribers. Based on a survey conducted, they expect to lose 20 subscribers for each $\$ 0.10$ increase from the current monthly subscription price. What should the newspaper company charge for a monthly subscription in order to maximize the income from the print newspaper subscriptions?
A. \$1.35
B. $\$ 9.30$
C. \$10.65
D. $\$ 22.80$

Correct answer: C level: 4
55. From 2004 to 2007, the number of cars produced in China, in thousands, can be approximated by a quadratic function. The minimum production during this time occurred in 2004 with China producing approximately 5234.5 thousand cars during that year. The following year, China produced 5707.69 thousand cars. According to the data, approximately how many cars did China produce in 2006 ?
A. 1893 thousand
B. 3815 thousand
C. 6181 thousand
D. 7127 thousand

Correct answer: D level: 4
56. Dalia tosses a ball to Kaylee. The ball travels along the path of a parabola and reaches a maximum height of 10ft above ground level after traveling a horizontal distance of 5 ft . Let $x$ represent the horizontal distance the ball has traveled, and let $y$ represent the height of the ball above ground level. If Dalia releases the ball at an initial height of 3 ft , which of the following functions models the path of the ball?
A. $y=3(x-5)^{2}+10$
B. $y=-3(x-5)^{2}+10$
C. $y=\frac{7}{25}(x-5)^{2}+10$
D. $y=-\frac{7}{25}(x-5)^{2}+10$

Correct answer: D level: 4
57. Tonya hits a golf ball from an initial height of 10 feet. The height of the golf ball, $h$, in feet above sea level, $t$ seconds after the ball was hit, can be modeled by a quadratic function. If the golf ball reaches its maximum height of 74 feet exactly 2 seconds after it has been struck, which of the following functions best models the height of the golf ball?
A. $h(t)=10(t-2)^{2}+74$
B. $h(t)=-10(t+2)^{2}+74$
C. $h(t)=-16(t-2)^{2}+74$
D. $h(t)=16(t+2)^{2}+74$

Correct answer: C level: 4
58. The present value ( $P V$ ) of an investment is the amount that should be invested today at a specified interest rate in order to earn a certain amount at a future date. The amount desired is called the future value. For a future value of $\$ 10,000$, which of the following functions models the present value, $P V$, to be invested in a savings account earning $5 \%$ interest compounded annually for $t$ years?
A. $P V(t)=10,000(1.05)^{t}$
B. $P V(t)=10,000(1.05)^{-t}$
C. $P V(t)=10,000(1+0.05 t)$
D. $P V(t)=10,000(1-0.05 t)$

Correct answer: B level: 4
59. Thomas tosses a ball upward into the air from an initial height of 1.475 meters. The height of the ball above the ground, $h$, in meters, $t$ seconds after the ball is tossed can be modeled by a quadratic function. If the ball reaches its maximum height of 12.5 meters exactly 1.5 seconds after the ball is tossed, approximately how long will the ball be in the air?
A. 1.6 seconds
B. 3.0 seconds
C. 3.1 seconds
D. 4.9 seconds

Correct answer: C level: 4
60. Wang Lei would like to build a $144 \mathrm{ft}^{2}$ rectangular garden. He plans to enclose this area with exactly 50 ft of fencing. Which of the following equations could be used to find the width, $x$, of Wang Lei's garden?
A. $x(72-x)=50$
B. $x(25-x)=144$
C. $x(144-2 x)=50$
D. $x(50-2 x)=144$

Correct answer: B level: 4
61. A squirrel jumps from a branch that is 7 meters above the ground and lands on another branch at the same exact height, exactly 0.4 seconds later. The squirrel's height above the ground, in meters, $t$ seconds after leaving the first branch, can be modeled by a quadratic function of the form $H(t)=-16(t-h)^{2}+k$. What is the squirrel's height above the ground, in meters, exactly 0.3 seconds after leaving the first branch?

Correct answer: 7.48 level: 4
62. E. coli is among the fastest-growing bacteria, with a generation (or doubling) time of 20 minutes under optimal conditions. After 60 minutes, the number of bacteria in a culture of $E$. coli was 400 . Approximately how many bacteria were in the culture after 30 minutes?
A. 50
B. 142
C. 174
D. 200

Correct answer: B level: 4
63. Mason sells bottled water at his town fair during the summer, setting the price per bottle in the morning for the entire day. The table below shows approximately how many bottles of water, $y$, Mason expects to sell in a day, based on the given price per bottle, $p$. According to the data, which of the following equations best models the amount of money, $S$, that Mason expects to collect in one day from his water sales?
A. $S=440-20 p$
B. $S=560-80 p$
C. $S=440 p-20 p^{2}$
D. $S=560 p-80 p^{2}$

| Price per bottle, $p$ | Expected bottles sold, $y$ |
| :---: | :---: |
| $\$ 2.00$ | 400 |
| $\$ 2.25$ | 380 |
| $\$ 2.50$ | 360 |
| $\$ 2.75$ | 340 |
| $\$ 3.00$ | 320 |

Correct answer: D level: 4
64. Bushels of corn exported from the U.S., in millions, from 2008 to 2012, can be modeled by a quadratic function. In 2008, the U.S. exported approximately 1849 million bushels of corn. In2009, the U.S. exported approximately 1979 million bushels of corn, which was a maximum for that time period. According to the above information, which of the following best approximates the U.S. corn exports in 2012?
A. 809 million bushels
B. 1170 million bushels
C. 1589 million bushels
D. 2369 million bushels

Correct answer: A level: 4
65. Anna would like to surround an 8 in $\times 10$ in photograph with a border of uniform width. Let $x$ be the width of the border, in inches. Which of the following functions could she use to determine the area, $A$, in square inches (in ${ }^{2}$ ), of the picture and border combined?
A. $A=(8-x)(10-x)$
B. $A=(8-2 x)(10-2 x)$
C. $A=(8+x)(10+x)$
D. $A=(8+2 x)(10+2 x)$

Correct answer: D level: 4
66.

Speed (in $\frac{\mathrm{km}}{\mathrm{hr}}$ ) Stopping distance (in m)

| 60 | 56 |
| :--- | :--- |
| 80 | 88 |

The data in the table above shows the approximate distance, $d$, that an average size vehicle traveling at a speed of $x$ kilometers per hour $\left(\frac{k m}{h r}\right)$ needs to stop. Note that the distance recorded is the sum of a reaction distance and a breaking distance. The stopping distance of a vehicle is a quadratic function of the vehicle's speed and can be modeled by a function of the form $d=a x^{2}+b x$. If a vehicle was traveling at a rate of $100 \frac{\mathrm{~km}}{\mathrm{hr}}$, which of the following best approximates the minimum distance needed to stop?
A. 93.
B. 110 m
C. 120 m
D. 127 m

Correct answer: D level: 4
67. Under ideal conditions, Lemna minor (common duckweed) is a fast-growing fern that can double its area every 2 days. Assume the growth is unrestricted, and that the duckweed initially covers10 square centimeters $\left(\mathrm{cm}^{2}\right)$ in area. Which of the following functions, $F$, models the area (in $\mathrm{cm}^{2}$ ) the duckweed covers after $d$ days?
A. $F(d)=10 \cdot(0.5)^{\frac{d}{2}}$
B. $F(d)=2 \cdot 10^{d}$
C. $F(d)=10 \cdot 2^{d}$
D. $F(d)=10 \cdot 2^{\frac{d}{2}}$

Correct answer: D level: 4
68. Black tea is prepared by pouring boiling water $\left(100^{\circ} \mathrm{C}\right)$ onto tea leaves and allowing the tea to brew in a pot or cup. In a room whose temperature is $20^{\circ} \mathrm{C}$, the tea reaches a temperature of $60^{\circ} \mathrm{C}$ after about 4 minutes.
The temperature of the tea as a function of time can be modeled by an exponential function. Which of the following functions, $T$, best models the temperature of the cup of tea $t$ minutes after pouring boiling water onto the leaves?
A. $T(t)=20+80 \cdot(0.84)^{t}$
B. $T(t)=80+20 \cdot(0.84)^{t}$
C. $T(t)=80 \cdot(0.84)^{t}$
D. $T(t)=100 \cdot(0.84)^{t}$

Correct answer: A level: 4
69. There is an exponential relationship between the amount of carbon dioxide, in
gigatons (Gt), emitted into the atmosphere per year due to fossil-fuel burning and cement manufacture. In 1850, the carbon dioxide emitted was about 1.00Gt, and in 1950, the carbon dioxide emitted was about 9.72Gt. What is the ratio of one year's carbon dioxide emissions to the previous year's carbon dioxide emissions?
A. 0.023
B. 1.023
C. 2.023
D. 3.023

Correct answer: B level: 4
70. The average computer's processor speed, S , in megahertz ( MHz ) has been increasing over time. In 1990, the speed was 1 MHz . In 1992, the speed was 3.2 MHz . In 2000, the speed was 319.3 MHz . In 2002, the speed was 1011.6 MHz . The relationship can be represented by the equation $S=a^{(Y-1990)}$, where $Y$ is the year. What is the value of $a$ to the nearest integer?

Correct answer: 2 level: 4
71. A bucket is full with hot water at a temperature of 100 degrees Celsius. The bucket is placed outside where the air has a constant temperature. Every hour that the water cools, the difference between the water temperature and the air temperature becomes $\frac{1}{10}$ of its previous difference. After 3 hours, the water temperature is 7.093 degrees Celsius. What is the temperature of the outside air, to the nearest degree Celsius?

Correct answer: 7 level: 4
72.

World Cumulative Installed Wind Power Capacity, 1980 - 2010 Time (in years) Wind power (in gigawatts)

| 1985 | 2.28 |
| ---: | ---: |
| 1995 | 11.89 |
| 2001 | 32.02 |
| 2005 | 61.97 |
| 2009 | 119.93 |

The table above models the progress of the world's wind power in gigawatts over
time in years. If this exponential trend continues, in what year will the world's wind power reach 1,200gigawatts, to the nearest year?

Correct answer: 2023 level: 4
73. A small pendulum is released in water. The maximum height that the pendulum reaches each time it swings decreases over time. Over the course of every 180 seconds, the pendulum's maximum height is reduced by $90 \%$. If the pendulum has been swinging for 360 seconds and now reaches a maximum height of 0.031 centimeters, what was the maximum height of the pendulum when it was initially released?

Correct answer: 3.1 level: 4
74. Carbon-14 is a radioactive isotope used to determine the age of samples of organic matter. The amount of carbon-14 in a sample decreases once the organism is no longer alive. The half-life of carbon-14 is approximately 5730 years. This means that every 5730 years, the amount of carbon-14 in an organism that is no longer living will be halved. Which of the following functions, $C$, models the fraction of carbon-14 remaining in a sample after $t$ years?
A. $C(t)=2^{\frac{t}{5730}}$
B. $C(t)=2^{-\frac{t}{5730}}$
C. $C(t)=2^{-5730 t}$
D. $C(t)=2^{5730 t}$

Correct answer: B
level: 4

## Manipulating quadratic and exponential expressions

1. The following equation shows the number of possible distinct passwords, $p$, of length, $L$, where each character is selected from $n$ permitted characters.

$$
p=n^{L}
$$

How does the number, $p$, of possible distinct passwords change if the length is increased by 3 characters?
A. $p$ is multiplied by $n^{3}$.
B. $p$ is multiplied by $3 n$.
C. $p$ is cubed.
D. $p$ is multiplied by 3 .

Correct answer: A level: 1
2. $F(r)=-\frac{A R}{6 r^{2}}$

The ability of geckos to climb on sheer surfaces has been attributed to the van der Waals forces between these surfaces and the microscopic spatulae which cover the hair on their footpads. The van der Waals force $F(r)$, measured in micronewtons, between a sphere (representing a spatula) of radius $R$ microns, and a plane (the wall), is shown above, where $r$, in nanometers, is the distance from the wall and $A$ is a constant. If the distance, $r$, decreases by $50 \%$, which of the following describes the effect on the van der Waals force?
A. The magnitude of the force doubles.
B. The magnitude of the force quadruples.
C. The magnitude of the force decreases by $50 \%$.
D. The magnitude of the force increases by $50 \%$.

Correct answer: B level: 1
3. $f_{D}=\frac{343}{343-v} f$

The Doppler effect describes the change in frequency of a sound created by an object as it approaches and moves past an observer. A train traveling at a speed of $v$ meters per second $\left(\frac{m}{s}\right)$ is emitting a sound of frequency $f$ Hertz. The Doppler frequency, $f_{D}$, as the train approaches the observer, is given by the equation above, where $343 \frac{\mathrm{~m}}{\mathrm{~s}}$ is the speed of sound. What is the effect on the Doppler frequency if the speed of the train, $v$, is doubled?
Please choose from one of the following options.
A. The Doppler frequency is doubled.
B. The Doppler frequency is halved.
C. The Doppler frequency increases, but it does not double.
D. The Doppler frequency decreases, but it is not halved.

Correct answer: C
level: 1
4. The surface of a road curves like a parabola to allow water to drain off of it. The following equation shows the surface height, $y$, in feet above the base at a point $x$ feet from the left edge of the road.

$$
y=-0.0015 x(x-40)
$$

The base has the same width as the road.
What is the width of the road?
Correct answer: 40 feet level: 1
5. The equation below can be used to calculate the kinetic energy, $K$, of an object having a mass, $m$, and a velocity, $v$.

$$
K=\frac{1}{2} m v^{2}
$$

If the velocity of Niklas's car slows to $\frac{2}{3}$ of its previous velocity, what will be the effect on the kinetic energy of the car?
A. The kinetic energy will become $\frac{2}{3}$ of the previous amount.
B. The kinetic energy will become $\frac{4}{9}$ of the previous amount.
C. The kinetic energy will become $\frac{1}{3}$ of the previous amount.
D. The kinetic energy will become $\frac{1}{9}$ of the previous amount.

Correct answer: B level: 1
6. The following function gives the amount of money owed on a short term loan after $t$ weeks.
$A(t)=100 \cdot 1.25^{\frac{t}{2}}$
Which numerical expression best approximates the annual interest rate, excluding any late fees? ( 1 year $=52$ weeks.)
A. $1-0.25^{26}$
B. $1.25^{26}-1$
C. $26 \cdot 0.25$
D. $26 \cdot 1.25$

Correct answer: B
level: 2
7. The rabbit population in an isolated forest rises and falls depending on the population of predators. Within the year 2014, the population, $p$, in thousands of rabbits $m$ months after January 1, 2014 is:
$p=0.05(m-1.5)(m-8.5)+10$
The population reached ten thousand some time in February. At what other time, given as months after January 1, 2014, did the rabbit population reach ten thousand?

Correct answer: 8.5 level: 2
8. The "hang time" of a football is the amount of time the football stays in the air after being kicked. The height, in meters, of the football above the ground at time $t$ can be modeled by the quadratic function:
$h(t)=-4.9 t 2+19.6 t$
Which of the following equivalent expressions displays the hang time of the football as a constant or coefficient?
A. $-4.9(t-2)^{2}+19.6$
B. $-4.9 t(t-4)$
C. $-4.9(t-3)^{2}-9.8 t+44.1$
D. $-4.9(t-1)^{2}+9.8 t+4.9$

Correct answer: B level: 2
9. Kaia throws a stone vertically upward from a bridge. The height, in meters, of the stone above the water at time $t$ can be modeled by the quadratic function:
$h(t)=-4.9 t^{2}+9.8 t+39.2$
After how many seconds does the stone hit the water?
A. 1 second
B. 2 seconds
C. 4 seconds
D. 8 seconds

Correct answer: C level: 2
10. An umbrella sprinkler is positioned on a ceiling at a point whose $x$-coordinate is 0 . Negative values of $x$ indicate distances, in meters, to the left of the position of the sprinkler, and positive values indicate distances to the right.
The path of water from the sprinkler can be modeled by the quadratic function

$$
w(x)=-\frac{1}{4}\left(x^{2}-12\right)
$$

where $w(x)$ is the height of the water, in meters, at position $x$.

Which of the following equivalent expressions displays the height of the ceiling as a constant or coefficient?

A. $-\frac{1}{4} x^{2}+3$
B. $-\frac{1}{4}(x-\sqrt{12})(x+\sqrt{12})$
C. $-\frac{1}{4}(x-2)(x+2)+2$
D. $-\frac{1}{4}(x-4)(x+4)-1$

Correct answer: A level: 2
11. Ariel was playing baseball and hit the ball into the air with a baseball bat. The height, $h$, in feet, of the ball $t$ seconds after it left her bat is modeled by the equation below:
$h(t)=-16 t^{2}+64 t+4$
How many seconds after leaving Ariel's bat does the ball reach its maximum height?
A. 2 seconds
B. 4 seconds
C. 8 seconds
D. 16 seconds

Correct answer: A
level: 2
12. Amelia is a meteorologist measuring the movement of air at a warm front using an airborne sensor. She finds that the elevation, $E$, in meters of a particular volume of air $t$ seconds after the start of recording is approximately: $E=20+0.08(t-5)^{2}$
What was the elevation in meters of the volume of air at the start of recording?
Correct answer: 22 level: 2
13. The following function, $L$, gives the approximate percent literacy rate in India $t$ years after 1900.
$L(t)=5.3 \cdot 1.025^{t}$
Which of the following equivalent functions shows, as a constant or coefficient, the approximate number of years it took for the literacy rate to triple?
A. $L(t)=5.3 \cdot 3^{\frac{t}{44.5}}$
B. $L(t)=5.3 \cdot 1.077^{\frac{t}{3}}$
C. $L(t)=5.3 \cdot 1.008^{3 t}$
D. $L(t)=3 \cdot 1.025^{t+23}$

Correct answer: A level: 2
14. A new cylindrical grain silo is being built to replace the old silo by enlarging its radius. The height, 15 meters ( m ), will stay the same. The approximate volume, in $\mathrm{m}^{3}$, of the new silo is given by the equation
$V(x)=\pi\left(15 x^{2}+180 x+540\right)$
where $x$ is the additional length of the new radius in meters.
What is the approximate radius of the old silo?
A. 3 m
B. 6 m
C. 15 m
D. 90 m

Correct answer: B
level: 2
15. Reem owns a stock option whose profit, $P$, in thousands of dollars depends on the stock price after one year, $s$, in dollars. Assuming $0 \leq s \leq 15$ and a negative profit represents a positive loss, then the value of $P$ is:
$P=31 s^{2}-5 s+18$
For which stock price after one year, in dollars, will Reem incur the greatest loss?
Correct answer: 7.5 level: 2
16. The Golden Years Senior Citizen Center uses a phone tree to announce when the center will be closed for poor weather. When each person receives a phone call, that person has a list of three more people to call. The function $c$ approximates the total number of calls made after $m$ minutes since the start of the phone tree.
$c(m)=\frac{3}{2}\left(3^{\frac{m}{10}}-1\right)$
Which function shows the approximate hourly growth rate as a constant or coefficient?
A. $c(m)=\frac{3}{2}\left(0.5^{60 m}-1\right)$
B. $c(m)=\frac{3}{2}\left(1.2^{60 m}-1\right)$
C. $c(m)=\frac{3}{2}\left(18^{\frac{m}{60}}-1\right)$
D. $c(m)=\frac{3}{2}\left(729^{\frac{m}{60}}-1\right)$

Correct answer: D
level: 3
17. A steel ball is traveling through water with a speed of $s$ meters per second, where $s$ is positive. The drag force, $F$, in newtons ( $N$ ) is:
$F=0.5+0.004(s+50)(s-2.5)$
At what speed in meters per second does the ball have a force of 0.5 N on it?
Correct answer: 2.5 level: 3
18. An ultrasound technician sometimes uses microbubbles as a contrast agent to improve the clarity of ultrasounds. However, the technician has a limited time to work, since the ultrasound process quickly destroys the microbubbles.

The following expression represents the concentration, in microbubbles per milliliter, of the microbubble suspension remaining in a client $t$ seconds after the technician has begun the ultrasound process.
$100,000,000 \cdot 0.5^{\frac{t}{120}}$
Which expression shows the multiple of the concentration remaining each minute as a constant or coefficient?
A. $100,000,000 \cdot \sqrt{0.5^{60}}$
B. $100,000,000 \cdot 0.5^{\frac{t}{60}}$
C. $100,000,000 \cdot 0.5^{60 t}$
D. $100,000,000 \cdot\left(0.5^{2}\right)^{60 t}$

Correct answer: A
level: 3
19. The height, $h$, in feet, of a baseball $t$ seconds after Tobin hit it with a baseball bat can be modeled by the equation below:
$h(t)=-16 t^{2}+64 t+4$
Which of the following equivalent expressions displays the value of the baseball's maximum height as a constant or coefficient?
A. $-16(t-2)^{2}+68$
B. $-4 t(4 t-16)+4$
C. $-16\left(t^{2}-4 t-41\right)$
D. $-16\left(t^{2}-4 t\right)+4$

Correct answer: A level: 3
20. A manufacturer of chemical glassware needs to purchase a certain amount of raw material. The profit, $p$, in dollars expected from purchasing $t$ tons of raw material, where $t$ is positive, is:
$p=50,000$ ( $2 t-1$ ) ( $t-5$ )
What is the smallest amount of raw material in tons that the manufacturer can purchase to breaks even with a profit of 0 dollars?

Correct answer: 0.5 level: 3
21. A gemcutter wants to trim a gemstone that is approximately a regular octahedron with sides measured in millimeters (mm). She will remove imperfections by reducing the length of each side by $x \mathrm{~mm}$.
The approximate new surface area is given in $\mathrm{mm}^{2}$ by the function:

$$
S(x)=3.4\left(56.25-15 x+x^{2}\right)
$$

What is the current length of each side?
A. 3.4 mm
B. 7.5 mm
C. 15 mm
D. 25.5 mm

Correct answer: B
level: 3
22. A water fountain creates a thin arc of water in the shape of a parabola. The path of the water coming from the fountain can be modeled by the quadratic equation

$$
w(x)=-0.022 x^{2}+0.84 x
$$

where $x$ is the distance, in feet, from the water source in the direction of the arc
and $w(x)$ is the height of the water, in feet.
Which of the following approximately equivalent expressions shows the maximum height of the water?

A. $-0.022 x(x-38)$
B. $-0.022\left(x^{2}-38 x\right)$
C. $-0.022(x-19)^{2}+7.9$
D. $-0.022\left((x-18)^{2}-2 x-324\right)$

Correct answer: C
level: 3
23. Abhishek received an injection of a medication. The following expression shows the number of milligrams of medication left in his body after $t$ hours.

$$
37 \cdot 0.25^{\frac{t}{16}}
$$

Half-life of a medicine refers to the amount of time it takes for half of the medicine to leave the body. What is the half-life (in hours) of Abhishek's medicine?

Correct answer: 8 hours level: 3
24. The amount of money, $A$, in dollars that is in Antoine's bank account after $t$ years can be shown with the function below.

$$
A(t)=2500 \cdot 1.005^{t}
$$

Which function represents the amount of money in Antoine's bank account after $m$ months?
A. $A(m)=2500 \cdot\left(1+\frac{0.005}{12}\right)^{m}$
B. $A(m)=2500 \cdot 1.005^{\frac{m}{12}}$
C. $A(m)=2500 \cdot\left(\frac{0.005}{12}\right)^{m}$
D. $A(m)=\frac{2500}{12} \cdot 1.005^{m}$

Correct answer: B
level: 3
25. A solar heater can be made from a parabolic mirror (that is, a mirror whose cross-sections are parabolas) by reflecting sunlight onto the focus of the parabola. If $f$ is the focal length of the parabola, then the function

$$
4 f y=x^{2}
$$

describes a cross-section of the parabolic mirror.
A. What is the focal length of a parabolic mirror whose cross-section is given by the function $y=\frac{1}{40} x^{2}$ ?

B. $\frac{1}{4}$
C. $\frac{1}{10}$
D. 10
E. 40

Correct answer: C
level: 3
26. Chang is measuring the speeds of stars as they travel around a black hole. She notices that the speed, $s$, in kilometers per second $t$ days after March $1^{\text {st }}$ is given by:
$s(t)=100+30 t-(t-2)^{2}$
Which of the following expressions for the star's speed is equivalent to the expression above and contains the maximum speed of the star as a constant or coefficient?
A. $96+34 t-t^{2}$
B. $-(t-17)^{2}+385$
C. $-(t-34)^{2}+385$
D. $104+30 t-t^{2}$

Correct answer: B
level: 3
27. The Golden Gate Bridge is a suspension bridge that consists of two cables hung from two towers of equal height that are approximately 1280 m apart. The height of the cable above the ground, in meters, can be modeled by the quadratic function

$$
h(x)=0.000371(x-640)^{2}
$$

where $x$ is the distance in meters measured from the left tower.
Which of the following approximately equivalent expressions displays the height of the tower as a constant or coefficient?

A. $0.000371 x^{2}-0.47488 x+151.9616$
B. $0.000371\left(x^{2}-1280 x+409,600\right)$
C. $0.000371\left((x-600)^{2}-80 x+49,600\right)$
D. $0.000371\left((x-650)^{2}+20 x-12,900\right)$

Correct answer: A level: 3
28. In one hour, the distance, $d(s)$, in kilometers that a ferry can travel up and down a river flowing with a constant speed, $s$, in meters per second is:
$d(s)=10.7-1.2 s 2$
where $s$ and $d(s)$ are positive. Which of the following equivalent expressions for $d(s)$ contains the speed of the river in meters per second, as a constant or coefficient, for which the ferry can travel a distance of 8 kilometers in one hour?
A. $8-1.2(s-1.5)(s+1.5)$
B. $8+1.2\left(2.25-s^{2}\right)$
C. $8\left(1-0.15 s^{2}\right)+2.7$
D. $11.9-1.2(s-1)^{2}-2.4 s$

Correct answer: A level: 3
29. The path of water from an umbrella sprinkler mounted on a ceiling can be modeled by the quadratic function

$$
w(x)=-\frac{1}{3} x^{2}+3
$$

where $x$ is the distance from the point on the ground below the sprinkler.
Negative values of $x x$ indicate distances to the left of the position of the sprinkler, and positive values indicate distances to the right. The area under the graph is called the "protected area."

Which of the following equivalent expressions displays, as a constant or coefficient, the maximum width from the center that is protected by the sprinkler?

A. $-\frac{1}{3}\left(x^{2}-9\right)$
B. $-\frac{1}{3}(x-3)(x+3)$
C. $-\frac{1}{3}(x-1)(x+1)+\frac{8}{3}$
D. $-\frac{1}{3}(x-2)(x+2)+\frac{5}{3}$ Correct answer: B level: 3
30. Sediment in water lowers the intensity of light shining through the water. The following function, $C$, gives the light intensity, in candela per square meter, of light at a depth of $d$ meters in a particular body of water.

$$
C(d)=9300 \cdot 0.8^{d}
$$

Which of the following equivalent functions shows the approximate percent change per centimeter as a constant or coefficient?
Please choose from one of the following options.
A. $C(d)=0.0000019 \cdot(1-0.2)^{d-100}$
B. $C(d)=9279 \cdot(1-0.2)^{d+100}$
C. $C(d)=9300 \cdot(1-0.002)^{100 d}$
D. $C(d)=9300 \cdot\left(1-2 \cdot 10^{-10}\right)^{\frac{d}{100}}$

Correct answer: C level: 3
31. Lúcia posted a video of her cat playing on the piano. She found that the following expression modeled the total number of people who had viewed her video $t$ days after she posted it.
$18 \cdot 16^{0.0125 t}$
After how many days did the total number of people viewing the video double from the original number of people? Round to the nearest day.

Correct answer: After 20 days level: 3
32. A small business models its weekly revenue (the product of the number of units sold and the price per unit) by the quadratic function

$$
R(x)=50 x-0.1 x^{2}
$$

where $x$ is the number of units sold.
What is the maximum weekly revenue of the business?
A. $\$ 625$
B. $\$ 6,250$
C. $\$ 25,000$
D. $\$ 62,500$
33. A mug of warm apple cider is gradually cooling. Its temperature in degrees Celsius $\left({ }^{\circ} \mathrm{C}\right)$ can be modeled with the expression $24+25 \cdot 2^{-0.014 t}$, where the variable $t$ represents the time in minutes.
Which expression shows, within the parentheses, the hourly decay rate of the difference between the initial temperature and the ambient temperature?
A. $24+25\left(60 \cdot 2^{-0.014}\right)^{t}$
B. $24+25\left(\frac{2}{60}-0.014\right)^{t}$
C. $24+25 \cdot\left(2^{-0.014 \cdot 60}\right)^{\frac{t}{60}}$
D. $24+25 \cdot\left(2^{\frac{-0.014}{60}}\right)^{60 t}$

Correct answer: C level: 3
34. Black-footed ferrets are the only ferret species native to North America, but they were nearly extinct in the 1970's. Since then, efforts have been made to breed the ferrets in captivity and reintroduce them to the wild. The following function represents the current goal population, $f$, of ferrets. The goal population is the number of mature black-footed ferrets that the conservationists hope to have living in the wild $t$ years after 1991.

$$
f(t)=51.35 \cdot 1000^{\frac{2 t}{125}}
$$

To the nearest year, how long will it take for the goal population to increase to 1010 times the goal population of a given year?
A. 4 years
B. 21 years
C. 51 years
D. 63 years

Correct answer: B level: 3
35. In game theory, the average branching factor refers to the average number of legal moves available to a player at each turn. In chess, the average branching factor is about 35 .
If Jules wants to write a chess simulation program that represents every possible sequence of moves in a game that lasts $n$ moves, the following function approximates the number of distinct sequences $s(n)$ he would simulate.

$$
s(n)=35^{n}
$$

How many times greater does the number of sequences become each time the game lasts 2 moves longer?

Correct answer: 1225 level: 3
36. The path of an atom where $x$ is the east coordinate in millimeters and $y$ is the north coordinate in millimeters from a sensor is:
$x=y^{2}-4 y+5$
Among all points along the atom's path, what is the smallest east coordinate in millimeters?

Correct answer: 1 level: 4
37. An electronics company has modeled its profits, in dollars, from the sale of smartphones by the quadratic function
$P(x)=-0.05 x^{2}+1,000 x$
where $x$ is the number of units sold.
Which of the following equivalent expressions displays the number of units that must be sold to maximize profit as a constant or coefficient?
A. $-0.05\left(x^{2}-20,000 x\right)$
B. $-0.05(x-10,000)^{2}+5,000,000$
C. $-0.05 x(x-20,000)$
D. $-0.05\left(x^{2}-5,000 x\right)+750 x$

Correct answer: B level: 4
38. An intermediate chemical is formed during a chemical reaction. Assuming the mass is positive, the mass of the intermediate chemical, $m$, in grams $t$ milliseconds after mixing the initial chemicals is given by:
$m=-18.79(t-3.68)(t-7.58)$
According to the model, how long, in milliseconds, did the intermediate chemical have positive mass?

Correct answer: 3.9 level: 4
39. The function $P$, below models the population, in millions of people, of Bangladesh from 1960 to2010, where $t$ is the number of years since 1960.
$P(t)=51.53 \cdot 1.022^{t}$
Which of the following equivalent functions displays the percent change in the population over the course of a decade as a constant or coefficient of the equation?
A. $P(t)=51.53 \cdot 0.1^{-0.0095 t}$
B. $P(t)=51.53 \cdot(1+0.002)^{10 t}$
C. $P(t)=51.53 \cdot(1+0.243)^{0.1 t}$
D. $P(t)=51.53 \cdot 10^{0.0095 t}$

Correct answer: C
40. A plane is travelling between the Hawaiian islands of Kauai and Oahu. The altitude, $a(x)$, in miles of the plane at a horizontal distance of $x x$ miles from Kauai is given by:

$$
a(x)=0.14 x-0.0014 x^{2}
$$

What is the maximum altitude, in miles, reached on this flight path?
Correct answer: 3.5 level: 4
41. A particular medicine is taken orally. Its concentration in the bloodstream, $C$, in milligrams per liter $t$ minutes after consumption is measured to be: $C=121-(t-18)^{2}$

The medicine enters the bloodstream as soon as $C$ is not negative. How many minutes after consumption does the medicine enter the bloodstream?

Correct answer: 7 level: 4
42. An architect has been commissioned to build a public landmark. She wants to design an enormous parabolic arch. The equation that models the height, $h$, of the arch $m$ meters away from the center is given by:
$h(m)=-\frac{1}{50} m^{2}+200$
Which of the following equivalent expressions displays, as a constant or coefficient, the distance from the center to where the arch meets the ground?

Note: Negative values of $m$ are to the left of the center of the arch and positive values are to the right.
A. $-\frac{1}{50}(m+100)(m-100)$
B. $-\frac{1}{50}\left(m^{2}-10,000\right)$
C. $-\frac{1}{50}(m+40)(m-40)+168$
D. $-\frac{1}{50}(m+50)(m-50)+150$

Correct answer: A
level: 4
43. The following function models the amount, $A$, of titanium-44, in millibecquerals, in a particular sample after $t$ years.

$$
A(t)=95 \cdot 0.99^{t}
$$

Which of the following equivalent expressions shows, as a constant or
coefficient, the amount of titanium-44 in the sample 3 years prior to initially measuring the sample?
Coefficients and constants have been rounded.
A. $92.18 \cdot 0.99^{t-3}$
B. $97.9 \cdot 0.99^{t+3}$
C. $95 \cdot 0.997^{3 t}$
D. $95 \cdot 0.97^{\frac{t}{3}}$

Correct answer: B level: 4
44. A train traveling at a speed of $s$ miles per hour applies its brakes before a buffer stop. Assuming $d \geq 0$ and $s \geq 0$, the distance, $d$, in yards from the train to the buffer stop once the train comes to rest is:
$d=0.5\left(-s^{2}-1.2 s+184.6\right)$
Which of the following equivalent expressions for $d$ contains the traveling speed of the train, as a constant or coefficient, for which the train rests right at the buffer stop after applying its brakes?
A. $-0.5 s^{2}-0.6 s+92.3$
B. $-0.5(s-13)(s+14.2)$
C. $-0.5(s+0.6)^{2}+92.48$
D. $(6.5-0.5 s)(s+14.2)$

Correct answer: B level: 4
45. A banking firm uses a particular algorithm to create models given a number of data entries, $n$. The algorithm's delay, $d$, measured in seconds per data entry is: $d=\frac{1}{35}(n-45)^{2}+450$

For how many data entries does the algorithm have the least delay?
Correct answer: 45 level: 4
46. A cereal company wants to enlarge the volume of the cylindrical container used for one of its products by enlarging the radius of the cylinder. The height must be 20 cm . The new volume of the cylinder is given by the equation

$$
V(x)=20 \pi(5+x)^{2}
$$

where $x$ is the additional length of the radius in centimeters.
Which of the following equivalent expressions displays as a constant or coefficient the present value of the volume of the cylinder?
A. $\pi\left(20 x^{2}+200 x+500\right)$
B. $20 \pi\left(x^{2}+10 x+10\right)+300 \pi$
C. $20 \pi\left(x^{2}+10 x+25\right)$
D. $20 \pi x^{2}+200 \pi x+500 \pi$

Correct answer: D
level: 4
47. The Consumer Price Index average price, $p(t)$, for a pound of ground beef chuck $t$ years since 2004 can be modeled using the function below.

$$
p(t)=2.4 \cdot 2^{0.06 t}
$$

Assuming the model continues to closely approximate the average price of beef, how many years will it take for the price to quadruple? Round to the nearest year.

Correct answer: 33 years level: 4
48. Manufacturers of chargers for lithium ion batteries establish a safety threshold, after which the charger reduces the current to the battery because overcharging the battery can damage it.
The following function, $A$, gives the current, in amps, of the charger $t$ hours after the battery has reached the safety threshold.

$$
A(t)=0.95 \cdot 0.36^{t}
$$

Which of the following equivalent functions best shows the approximate decay rate per 15 minutes as a constant or coefficient?
A. $A(t)=0.95 \cdot 0.017^{\frac{t}{4}}$
B. $A(t)=0.95 \cdot 0.77^{4 t}$
C. $A(t)=0.95 \cdot 0.0000002^{\frac{t}{15}}$
D. $A(t)=0.95 \cdot 0.93^{15 t}$

Correct answer: B level: 4
49. The energy, $E$, in joules of a vertical spring with a length of $L$ inches and at rest on the ground is calculated to be:
$E=20 L+5(L-6)^{2}$
According to the calculation, at what length, in inches, does the spring have a minimum energy?

Correct answer: 4 level: 4
50. The temperature, $T$, within a rod $x$ centimeters from the rod's left end is modeled by the following equation:

$$
T=-110+0.13 x(21-x)
$$

Both ends of the rod have the same temperature. According to the model, what is the length of the rod in centimeters?

Correct answer: 21 level: 4
51. The population of Japan, $p$, in millions of people at time $t$, where negative values of $t$ represent a number of years before January 1st, 2000 and positive values of $t$ represent a number of years after January 1st, 2000 is projected as: $p=128-0.012(t-9.17)^{2}$
According to this projection, during which year does Japan reach its maximum population?

Correct answer: 2009 level: 4
52. The following equation gives the amount owed, $A$, in dollars, on a credit card after $t$ years.

$$
A=150 \cdot 1.21^{t}
$$

What is the percent increase over any 6 month period? Do not type the percent sign.
Correct answer: $10 \%$ level: 4
53. Wang Xiu measured the brightness of a glowstick. The equation below models the brightness, $L$, in lumens, $h$ hours after activating the glowstick.
$L=4 \cdot 0.73^{h}$
Which equation best highlights the number of hours it would take for Wang Xiu's glowstick to lose $90 \%$ of its brightness?
A. $L=0.4 \cdot 0.73^{h}$
B. $L=3.6 \cdot 0.73^{h}$
C. $L=4 \cdot 0.1^{\frac{h}{7.3}}$
D. $L=4 \cdot 0.9^{2.987 h}$

Correct answer: C level: 4
54. The path of an atom where $x$ is the east coordinate in millimeters and $y$ is the north coordinate in millimeters from a sensor is:
$x=y^{2}-4 y+5$
Among all points along the atom's path, what is the smallest east coordinate in millimeters?

Correct answer: 1 level: 4

## Radicals and rational exponents

1. Simplify $\sqrt{77}$.
A. 77
B. $\sqrt{77}$
C. $7 \sqrt{11}$
D. $11 \sqrt{7}$

Correct answer: B level: 1
2. Simplify $\sqrt{43}$.
A. $\sqrt{43}$
B. 43
C. $4 \sqrt{3}$
D. $3 \sqrt{4}$

Correct answer: A level: 1
3. Simplify $\sqrt{49}$.
A. 49
B. $2 \sqrt{7}$
C. $7 \sqrt{2}$
D. 7

Correct answer: D
level: 1
4. Simplify $\sqrt{98}$.
A. $7 \sqrt{2}$
B. $2 \sqrt{7}$
C. $\sqrt{98}$
D. $2 \sqrt{49}$

Correct answer: A level: 1
5. Simplify $\sqrt{105}$.
A. $5 \sqrt{21}$
B. $7 \sqrt{15}$
C. 105
D. $\sqrt{105}$

Correct answer: D
level: 1
6. If $q^{3} \cdot\left(q^{4}\right)^{2}=q^{x}$, then which of the following is the value of $x$ ?
A. 9
B. 11
C. 18
D. 19

Correct answer: B level: 2
7. $\left(\frac{1}{2}\right)^{-2}+3^{0}$

What is the value of the above expression?
A. $-\frac{1}{4}$
B. $\frac{1}{4}$
C. 4
D. 5

Correct answer: D level: 2
8. $\sqrt[3]{24 v^{3} w^{8}}$

Which of the following is equivalent to the above expression?
A. $2 \mathrm{vw}^{23} \sqrt[3]{3}$
B. $8 \mathrm{vw} \sqrt{23} \sqrt{3}$
C. $2 \mathrm{vw} \sqrt{23} 3 w^{2}$
D. $8 \mathrm{vw} w^{23} \sqrt{3 w^{2}}$

Correct answer: C
level: 2
9. $2 \sqrt[3]{4} \cdot 2 \sqrt[3]{2}$

What is the value of the above expression?
A. 4
B. 8
C. 16
D. 32

Correct answer: B level: 2
10. $\left(\frac{64}{b^{27}}\right)^{-\frac{2}{3}}$

Which of the following is equivalent to the above expression?
A. $\frac{b^{9}}{16}$
B. $\frac{b^{8}}{16}$
C. $-\frac{128 b^{9}}{3}$
D. $-\frac{128 b^{18}}{3}$

Correct answer: B level: 2
11. $6^{\frac{1}{2}}+6^{\frac{3}{2}}$

Which of the following values is equal to the value above?
A. $\sqrt{222}$
B. $7 \sqrt{6}$
C. $6^{\frac{3}{4}}$
D. 36

Correct answer: B level: 3
12. $\left(\frac{3}{4}\right)^{1.5} \cdot\left(\frac{2}{3}\right)^{2.5}$

Which of the following values is equal to the value above?
A. $3^{-3.75} \cdot 2^{-7.5}$
B. $\frac{1}{16}$
C. $\frac{1}{3 \sqrt{2}}$
D. $\sqrt[4]{\frac{1}{8}}$

Correct answer: C level: 3
13. $\frac{\sqrt[4]{y} \sqrt{y}}{\sqrt[3]{y}}$

If the expression above is equal to $y^{M}$ for $y \neq 0$, then what is the value of $M$ ?
Correct answer: $5 / 12$ level: 3
14. $4^{\frac{1}{5}} \cdot 3^{\frac{2}{5}}=Y^{\frac{1}{5}}$

Given the above equation, what is the value of $Y$ ?
Correct answer: 36 level: 3
15. $\frac{x}{\sqrt[3]{x}}$

Which of the following is equivalent to the above expression for $x \neq 0$ ?
A. 1
B. $\sqrt[3]{x}$
C. $\sqrt[3]{x^{2}}$
D. $x^{3}$

Correct answer: C level: 3
16. $\frac{y+y^{2}}{y^{-\frac{2}{3}}}$

Which of the following expressions is equivalent to the expression above assuming $y$ is nonzero?
A. $y^{-\frac{2}{3}}+y^{-3}$
B. $y^{\frac{2}{3}}+y^{3}$
C. $y^{\frac{1}{3}}+y^{\frac{4}{3}}$
D. $y^{\frac{5}{3}}+y^{\frac{8}{3}}$

Correct answer: D
level: 3
17. $\left(\frac{1}{8}\right)^{-\frac{2}{3}}$

Which of the following is the value of the above expression?
A. $-\frac{1}{12}$
B. $\frac{1}{4}$
C. 4
D. 12

Correct answer: C level: 3
18. If $8^{\frac{5}{6}}-8^{\frac{1}{2}}=8^{m}$ for some value of mm , then which of the following is mm ?
A. $\frac{1}{3}$
B. $\frac{1}{2}$
C. 1
D. $\frac{5}{3}$

Correct answer: B level: 3
19. $\frac{\sqrt{8 c^{20}}}{\sqrt{32 c^{4}}}$

Which of the following is equivalent to the above expression for $c \neq 0$ ?
A. $\frac{1}{2} c^{4}$
B. $\frac{1}{2} c^{8}$
C. $\frac{1}{4} c^{16}$
D. $\frac{1}{4} c^{2} \sqrt{c}$
20. $\left(x^{\frac{7}{4}} \cdot x^{4}\right)^{4}$

Which of the following expressions is equivalent to the expression above assuming $x$ is nonzero?
A. $x^{\frac{39}{4}}$
B. $x^{11}$
C. $x^{23}$
D. $x^{28}$

Correct answer: C level: 3
21. $\sqrt{2 y^{3} z} \cdot \sqrt{8 y^{13} z^{8}}$

Which of the following is equivalent to the above expression for $y, z \geq 0$ ?
A. $4 y^{4} z^{3}$
B. $8 y^{4} z^{3}$
C. $4 y^{8} z^{4} \sqrt{z}$
D. $8 y^{8} z^{4} \sqrt{z}$

Correct answer: C level: 3
22. $y^{\frac{1}{2}} \cdot \sqrt[3]{16 x^{2} y^{\frac{3}{2}}+8 y^{2}}$

Which of the following expressions is equivalent to the expression above assuming $y \geq 0$ ?
A. $2 y \sqrt[3]{2 x^{2}+y^{\frac{1}{2}}}$
B. $\sqrt[3]{24 x^{2} y^{\frac{7}{2}}} \cdot y^{\frac{1}{2}}$
C. $y \sqrt[3]{16 x^{2}}+2 y^{\frac{7}{6}}$
D. $\sqrt[3]{16 x^{2} y^{2}+8 y^{\frac{5}{2}}}$

Correct answer: A level: 3
23. $4^{0}+0^{\frac{2}{3}}+1^{-5}$

Which of the following values is equal to the value above?
A. -1
B. 0
C. 1
D. 2

Correct answer: D level: 3
24. $\sqrt{0.05} \cdot \sqrt{15}$

Which of the following values is equal to the value above?
A. $\frac{\sqrt{3}}{2}$
B. $\frac{3}{4}$
C. $\sqrt[4]{0.75}$
D. 0.375

Correct answer: A level: 3
25. $\frac{\sqrt{75 x^{4}}}{\sqrt{12 x^{7}}}$

Which of the following expressions is equivalent to the expression above?
A. $\frac{5 x \sqrt{3 x}}{6}$
B. $\frac{5 \sqrt{3 x}}{6 x^{2}}$
C. $\frac{5}{2 \sqrt{x}}$
D. $\frac{5 \sqrt{x}}{2 x^{2}}$

Correct answer: D
level: 3
26. $\left(\frac{a^{7}}{a^{-3}}\right)^{0} \cdot \frac{a^{3}\left(a^{-2}\right)^{4}}{a^{7}}$

The expression above simplifies to $a^{x}$, for some integer $x$. What is the value of $x$ ?
A. -12
B. 0
C. 2
D. 12

Correct answer: A level: 3
27. $5^{\frac{1}{3}}-5^{\frac{4}{3}}$

Which of the following expressions is equivalent to the expression above?
A. $-4 \cdot 5^{\frac{1}{3}}$
B. $-\sqrt[3]{620}$
C. $5^{\frac{1}{4}}$
D. $\frac{1}{5}$

Correct answer: A level: 3
28. $2^{5} \cdot\left(\frac{1}{4}\right)^{7}$

Which of the following expressions is equivalent to the expression above?
A. $2^{-2}$
B. $2^{-4}$
C. $2^{-9}$
D. $2^{10}$

Correct answer: C
level: 3
29. $\sqrt[3]{25 g^{5} f^{2}} \cdot \sqrt[3]{5 g f^{2}}$

Which of the following expressions is equivalent to the expression above?
A. $5 g^{2} f^{3} \sqrt{f}$
B. $5 \mathrm{~g} f^{3} \sqrt{g^{2} f}$
C. $5 g^{3} f^{2} \sqrt{5}$
D. $\sqrt[9]{125 g^{5} f^{4}}$

Correct answer: A level: 3
30. $\frac{a^{2} a^{-5}}{a^{-3} a^{0}} \cdot\left(\frac{a^{2}}{a^{3}}\right)^{-4}=a^{x}$

What is the value of $x$ ?
Correct answer: 4 level: 3
31. $\sqrt[3]{a^{2}} \cdot \sqrt{b^{3}}$

Which of the following expressions is equivalent to the expression above?
A. $\sqrt[6]{a^{4} b^{9}}$
B. $\left(a^{2} b^{3}\right)^{\frac{5}{6}}$
C. $(\sqrt[3]{a} \sqrt{b})^{6}$
D. $\sqrt[3]{b^{2} \cdot \sqrt{a^{3}}}$

Correct answer: A level: 4
32. $\left(z^{\frac{1}{2}}+z^{\frac{3}{2}}\right)^{2}$

Which of the following expressions is equivalent to the expression above assuming $z \geq 0$ ?
A. $z^{4}$
B. $z+z^{3}$
C. $z^{\frac{5}{2}}+z^{\frac{7}{2}}$
D. $z+2 z^{2}+z^{3}$

Correct answer: D level: 4
33. $\sqrt[3]{x^{2}} \cdot x^{-\frac{1}{5}}$

Which of the following is equivalent to the above expression for $x \neq 0$.
A. $\sqrt[15]{x^{7}}$
B. $\sqrt[7]{x^{15}}$
C. $\frac{1}{\sqrt{15}}$
D. $\frac{1}{\sqrt[15]{x^{2}}}$

Correct answer: A level: 4
34. $\left(\frac{1}{9}\right)^{-1.5} \cdot\left(\frac{1}{8}\right)^{\frac{2}{3}}$

What is the value of the above expression?
Correct answer:27/4 level:4
35. $\sqrt[3]{64^{27}}$

Which of the following values is equivalent to the expression above?
A. $4^{3}$
B. $64^{3}$
C. $8^{18}$
D. $64^{24}$

Correct answer: C level: 4
36. $\frac{\left(\frac{1}{9}\right)^{124}}{\left(\frac{1}{3}\right)^{72}}$

Which of the following values is equal to the value above?
A. $3^{-176}$
B. $3^{-52}$
C. $3^{52}$
D. $3^{176}$
E.

Correct answer: A level: 4
37. $x^{\frac{3}{2}} \cdot\left(\frac{1}{x^{\frac{5}{2}}}\right)^{2}$

Which of the following is equivalent to the above expression for $x \backslash n e q 0 x \neq 0$ ?
A. $\frac{1}{x^{2}}$
B. $\frac{1}{\sqrt{x^{7}}}$
C. $\frac{1}{\sqrt[7]{x^{2}}}$
D. $\frac{1}{\sqrt[4]{x^{19}}}$

Correct answer: B
level: 4
38. $6^{\frac{1}{6}} \cdot 2^{\frac{5}{6}} \cdot 3^{\frac{7}{6}}$

Which of the following values is equal to the value above?
A. $6 \sqrt[3]{3}$
B. $2^{\frac{5}{36}} \cdot 3^{\frac{7}{36}}$
C. $36^{\frac{35}{216}}$
D. $\sqrt[3]{6^{13}}$

Correct answer: A level: 4
39. Which of the following expressions is equivalent to $\sqrt[4]{32^{16}}$ ?
A. $2^{20}$
B. $2^{625}$
C. $32^{2}$
D. $32^{12}$

Correct answer: A
level: 4
40. $\frac{2}{\sqrt{2}}(\sqrt{8}-\sqrt{50})$

What is the value of the above expression?
A. -17
B. -6
C. $-2 \sqrt{21}$
D. $4-\sqrt{5}$

Correct answer: B level: 4
41. $\frac{8^{\frac{1}{2}}}{2^{\frac{1}{3}}}$

Which of the following expressions is equivalent to the expression above?
A. $2^{\frac{7}{6}}$
B. $2^{\frac{9}{2}}$
C. $4^{\frac{1}{6}}$
D. $4^{\frac{3}{2}}$

Correct answer: A
level: 4
42. $\left(2 b^{-5}\right)^{3}$

Which of the following is equivalent to the above expression for $b \neq 0$ ?
A. $\frac{2}{b^{15}}$
B. $\frac{8}{b^{15}}$
C. $\frac{1}{2 b^{15}}$
D. $\frac{1}{8 b^{15}}$

Correct answer: B level: 4
43. $\sqrt{x} \cdot \sqrt{\frac{y^{5}}{x^{3}}}$

For $x, y \geq 0$, which of the following is equivalent to the above expression?
A. $x^{-2} y^{5}$
B. $x^{-1} y^{\frac{5}{2}}$
C. $x y^{\frac{5}{2}}$
D. $\frac{y^{\sqrt{5}}}{x^{\sqrt{2}}}$

Correct answer: B level: 4
44. The quotient of $\sqrt[5]{\sqrt[5]{m^{4}}} \sqrt{m^{3}}$ and $\frac{\sqrt{m}}{\sqrt[5]{m^{6}}}$ equals $m^{y}$ for some real $y$. What is the value of $y$ ? Correct answer: $3 / 4$ level: 4
45. $\frac{\sqrt{x}}{5 \sqrt[5]{x^{6}}}$

Which of the following expressions is equivalent to the expression above?
A. $\frac{1}{5 \sqrt[6]{x}}$
B. $\frac{1}{5 \sqrt[10]{x^{7}}}$
C. $\frac{x}{5 \sqrt[10]{x^{3}}}$
D. $\frac{\sqrt[7]{x}}{5}$

Correct answer: B level: 4

## Radical and rational equations

1. $\left(3^{-2}\right)^{0.5}$

What is the value of the expression above?
Correct answer: $1 / 3$ level: 1
2. $\frac{a^{8} b^{-2}}{a^{2} b^{10}}$

Which of the following is equivalent to the above expression for $a, b \neq 0$ ?
A. $a^{4} b^{-5}$
B. $a^{6} b^{12}$
C. $\frac{a^{4}}{b^{-5}}$
D. $\frac{a^{6}}{b^{12}}$

Correct answer: D level: 1
3. $\sqrt{16 x^{2} y^{16}+25 x^{16} y^{2}}$

If $x x$ and $y$ are positive, which of the following is equivalent to the above expression?
A. $4 x y^{8}+5 x^{8} y$
B. $4 x y^{4}+5 x^{4} y$
C. $x y \sqrt{16 y^{14}+25 x^{14}}$
D. $x^{2} y^{2} \sqrt{16 y^{14}+25 x^{14}}$

Correct answer: C level: 1
4. $\frac{2+\sqrt{2}}{2-\sqrt{2}}$

Which of the following is equivalent to the above expression?
A. -1
B. $1+\sqrt{2}$
C. $3+2 \sqrt{2}$
D. $3+4 \sqrt{2}$
5. $(b d)^{\frac{1}{4}} \cdot\left(\frac{b}{d}\right)^{4}$

Which of the following expressions is equivalent to the expression above assuming $d$ is nonzero?
A. $b^{\frac{17}{4}} d^{\frac{17}{4}}$
B. $b^{\frac{17}{4}} d^{-\frac{15}{4}}$
C. $b^{2}$
D. $\frac{b}{d}$

Correct answer: B level: 1
6. $2 \sqrt{9 x}-6=10-2 \sqrt{x}$

What value of $x x$ is the solution to the above equation?
Correct answer: 4 level: 2
7. $\mathrm{n}+2=\sqrt{a-n}$

For what value of the constant $a$ does the above equation have $n=1$ as the only solution?

Correct answer: 10 level: 2
8. $8 \sqrt{p}-2 \sqrt{3}=\sqrt{3}+3 \sqrt{p}$

What value of $p p$ is the solution to the above equation?
A. $\frac{3 \sqrt{3}}{5}$
B. $\frac{9}{5}$
C. $\frac{9}{25}$
D. $\frac{27}{25}$

Correct answer: D
level: 2
9. $4 p^{\frac{1}{2}}+5 p=0$

What is the least value of $p$ that is a solution to the above equation?
A. $-\frac{5}{4}$
B. $-\frac{4}{5}$
C. 0
D. $\frac{4}{5}$

Correct answer: C level: 2
10. $\mathrm{k}=\sqrt{10+3 k}-4$

What are all the possible values of $k$ that satisfy the equation above?
A. -2 only
B. 2 only
C. -2 and -3
D. 2 and -2

Correct answer: C
level: 2
11. $\mathrm{y}-\sqrt{7 y-31}=3$

What is the sum of all the solutions to the above equation?
A. -13
B. -3
C. 3
D. 13

Correct answer: D
level: 3
12. $\sqrt{l(l-5)}=6$

What is the sum of all solutions to the above equation?
Correct answer: 5 level: 3
13. $5-2 \sqrt{x}=7-5 \sqrt{x}$

Which value of $x$ is the solution to the above equation?
A. $\frac{2}{3}$
B. $\frac{4}{9}$
C. $\frac{9}{4}$
D. $\frac{4}{25}$
Correct answer: B
level: 3
14. $\sqrt{3 p+13}=p+3$

What is the sum of the solutions to the above equation?
Correct answer: 1 level: 3
15. $\frac{x}{x-2}+\frac{x}{(x-2)(x-3)}=\frac{4}{x-3}$

What are the solutions to the above equation?
A. 2 only
B. 4 only
C. 2 and 3
D. 2 and 4

Correct answer: B level: 3
16. $\frac{3 k}{k+4}-\frac{4 k}{k-2}=-5$

What are the values of $k$ that are solutions to the above equation?
A. -2 only
B. 5 only
C. -2 and 4
D. -2 and 5

Correct answer: D

$$
\text { level: } 3
$$

17. $7 x=13 \sqrt{x}$

What is the greatest value of $x$ that is a solution to the above equation?
A. 0
B. $\frac{49}{169}$
C. $\frac{169}{49}$
D. $\frac{13}{7}$

Correct answer: C level: 3
18. $\sqrt{4 x+20}=x+2$

What is the sum of the solutions to the above equation?
Correct answer: 4 level: 3
19. $\sqrt{y(y-15)}-4=0$

What is the sum of all solutions to the above equation?
Correct answer: 15 level:3
20. $3=\sqrt{2 x^{2}-5 x+39}-x$

What is the product of all solutions to the above equation?
Correct answer: 30 level: 3
21. $\sqrt{2 x+20}=2-\mathrm{x}$

What is the sum of the solutions to the above equation?
Correct answer: -2 level: 3
22. $\frac{-2 x-5}{5 x-3}+\frac{6 x-16}{6-10 x}=\frac{-1}{2}$

How many solutions does the equation above have?
A. 0
B. 1
C. 2
D. more than 2

Correct answer: A level: 3
23. $\sqrt{x^{2}-4 x+4}=0$

What is the product of all solutions to the above equation?
Correct answer:
2
level: 3
24. $\sqrt{3 m^{2}+24}=2 m+2$

What is the sum of all the solutions to the above equation?
A. -10
B. -8
C. 2
D. 8

Correct answer: C level: 3
25. $\sqrt{8 t}+13=10+4 \sqrt{2 t}$

What value of $t$ is the solution to the above equation?
A. $\frac{9}{16}$
B. $\frac{9}{8}$
C. $\frac{9}{4}$
D. $\frac{3}{2}$

Correct answer: B level: 3
26. $\sqrt{3 z+6}-\mathrm{z}=2$

What is the largest solution to the above equation?
Correct answer: 1 level: 3
27. $\frac{11 d+2}{d-8}=\frac{-3}{2}$

What is the solution to the equation above?
Correct answer: $4 / 5$ level: 3
28. $\frac{7 x-2}{4 x+6}=\frac{4 x-5}{6 x+9}+\frac{3 x-1}{2 x+3}$

What is the solution to the above equation?
Correct answer: 2
level: 3
29. $\sqrt{y+k}=\mathrm{y}+1$

For what value of the constant $k$ does the above equation have $y=1$ as the only solution?

Correct answer: 3 level: 3
30. $7 \sqrt{m}-6 \sqrt{2}=2 \sqrt{m}+4 \sqrt{2}$

Solve for $m$ in the above equation.
Correct answer: 8 level: 3
31. $\frac{-y}{y-3}-\frac{6}{y+2}=\frac{1}{2}$

What is the sum of all the solutions to the above equation?
Correct answer: -5 level: 4
32. $\sqrt{5 x^{2}-44}=3 x-8$

What is the sum of all the solutions to the above equation?
Correct answer:
level: 4
33. $\sqrt{6 r}=\sqrt{r^{2}-16}$

What is the product of all solutions to the above equation?
Correct answer: 8 level: 4
34. $w=\sqrt{108 w}$

What is the sum of all solutions to the above equation?
Correct answer:
108
level: 4
35. $\sqrt{3 x+7}=x+1$

What is the sum of the solutions to the above equation?
Correct answer: 3 level: 4
36. $\sqrt{6 x^{2}-50}=4 x-10$

What is the sum of all the solutions to the above equation?
Correct answer: 8 level: 4
37. $\frac{3 w}{w+4}-\frac{8}{w}=1$

What is the sum of all the solutions to the above equation?
Correct answer: 6 level: 4
38. $\frac{2 x}{x+3}-\frac{4}{x-2}=-3$

What is the sum for all the values of $x x$ that satisfy the equation above?
A. -2
B. 1
C. 3
D. 5

Correct answer: B level: 4
39. $\sqrt{2 x^{2}+7}+5=0$

How many real solutions does the above equation have?
A. 0
B. 1
C. 2
D. more than 2

Correct answer: A level: 4
40. $\frac{5}{k-2}-\frac{2 k-2}{k-1}=-1$

What is the sum of all the possible values for $k$ that satisfy the equation above?
Correct answer: 7 level: 4
41. $\frac{4 n}{n+3}-\frac{3 n}{n+4}=\frac{3 n-3}{(n+3)(n+4)}$

What is the sum of all the possible values for $n$ that satisfy the equation above?
Correct answer: -1 level: 4
42. $2 \mathrm{~h}-5=\sqrt{h^{2}+h-5}$

What is the sum of the solutions to the above equation?
Correct answer: $\square$ level: 4
43. $\frac{a}{a+2}+\frac{a}{a+1}=\frac{3 a+2}{(a+2)(a+1)}$

What is the sum of all the possible values for aa that satisfy the equation above?
Correct answer: $\square$ level: 4
44. $\frac{5}{z}-\frac{2 z+4}{z+2}=-3$

What is the sum of all the possible values for $z$ that satisfy the equation above?
Correct answer: -5 level: 4
45. $-\mathrm{m}+1=\sqrt{m+1}$

What is the sum of all solutions to the above equation?
Correct answer: 0 level: 4
46. $\frac{4 p}{p+1}=\frac{7 p+3}{(p+3)(p+1)}+\frac{3 p}{p+3}$

What is the sum of all the possible values for $p p$ that satisfy the equation above?
Correct answer:
47. $\frac{3 h}{h-2}+\frac{6}{h+2}=-1$

What is the sum of all the solutions to the above equation?
Correct answer: -3 level: 4
48. $\frac{x}{x-1}+\frac{4}{x-2}=\frac{4}{(x-1)(x-2)}$

What is the sum of all the possible values for $x$ that satisfy the equation above?
A. -4
B. -2
C. 1
D. 2

Correct answer: A level: 4
49. $\sqrt{5 k+3}=\sqrt{k+x}$

For what value of the constant $k$ does the above equation have $x=2$ as the only solution?

Correct answer: 11 level: 4
50. $\frac{15}{4 x-3}=7$

What is the solution to the equation above?
Correct answer: $9 / 7$ level: 4
51. $\sqrt{-2 p-1}=\mathrm{p}+2$

What is the sum of all solutions to the above equation?
A. -6
B. -5
C. -1
D. 1

Correct answer: C
level: 4

## Operations with rational expressions:

1. Simplify the following expression:
$\frac{-2 p+8}{2 p+2}$
A. $\frac{-p+8}{p+2}$
B. $\frac{-p+4}{2 p+2}$
C. $\frac{-p+4}{p+1}$
D. $\frac{p+4}{p+1}$

Correct answer: C
level: 1
2. Simplify the following expression:
$\frac{11 k-99}{110 k-22}$
A. $\frac{k-99}{10 k-2}$
B. $\frac{k-9}{10 k+2}$
C. $\frac{k-9}{10 k-2}$
D. $\frac{k-9}{11 k-2}$

Correct answer: C
level: 1
3. Simplify the following expression:
$\frac{-24 r^{2}-56 r}{-48 r^{2}+64 r}$
A. $\frac{-3 r+7}{-6 r+8}$
B. $\frac{-3 r-7 r}{-6 r+8 r}$
C. $\frac{3 r+7}{-6 r+8}$
D. $\frac{-3 r-7}{-6 r+8}$

Correct answer: D
level: 1
4. Simplify the following expression:
$\frac{-50 z^{2}+35 z}{-45 z^{2}+40 z}$
You can assume $z \neq 0$.
A. $\frac{-10 z+7}{-9 z+8}$
B. $\frac{10 z+7}{9 z+8}$
C. $\frac{-10 z+7}{-9 z-8}$
D. $\frac{-10 z+35}{-9 z+40}$

Correct answer: A
level: 1
5. Simplify the following expression:
$\frac{-12 a^{2}+96 a}{-12 a^{2}+60 a}$
You can assume $a \neq 0$.
A. $\frac{-a+8}{-a-5}$
B. $\frac{a+8}{-a+5}$
C. $\frac{-a+8}{-a+5}$
D. $\frac{-a+8 a}{-a+5 a}$

Correct answer: C
level: 1
6. $\frac{2 k}{3 k+12}+\frac{k+7}{k^{2}+4 k}$

Which expression is equivalent to the above sum?
A. $\frac{2 k^{2}+3 k+21}{3 k^{2}+12 k}$
B. $\frac{2 k^{2}+14 k}{3 k^{3}+24 k^{2}+48}$
C. $\frac{3 k+7}{k^{2}+7 k+12}$
D. $\frac{3 k+7}{k+4}$

Correct answer: A
level: 2
7. $\frac{49 m^{4} n-21 m^{6} n^{2}}{7 m^{2} n^{4}}$

Which expression is equivalent to the above for all $m>1$ and $n>1$ ?
A. $7 m^{2} n^{4}-3 m^{4} n^{2}$
B. $7 m^{2} n^{3}-3 m^{4} n^{2}$
C. $\frac{7 m^{2}-3 m^{3}}{n^{2}}$
D. $\frac{7 m^{2}-3 m^{4} n}{n^{3}}$

Correct answer: D level: 2
8. $\frac{4 k^{2}-12 k+9}{2 k^{2}+19 k-33} \cdot \frac{k^{2}+8 k-33}{k^{2}-3 k}$

Which expression is equivalent to the above product for $k \geq 33$ ?
A. $\frac{2 k-3}{k}$
B. $\frac{8\left(4 k^{2}+13\right)}{(2 k+9)}$
C. $\frac{\left(2 k^{2}+9\right)\left(2 k^{2}-33\right)}{4 k^{4}-57 k^{2}-33}$
D. $\frac{2 k^{4}+20 k^{3}-73 k^{2}+53 k-297}{k\left(k^{3}+13 k^{2}-30 k+11\right)}$

Correct answer: A
level: 2
9. $\frac{5 m^{2}+7 m}{2 m-9}-\frac{2 m}{2 m-9}$

Which expression is equivalent to the above difference?
A. $\frac{3 m^{2}+7 m}{2 m-9}$
B. $\frac{5 m^{2}+5 m}{2 m-9}$
C. $\frac{5 m+9 m}{2 m-9}$
D. $\frac{5 m^{2}+7 m-1}{2 m-9}$

Correct answer: B
level: 2
10. $\frac{5 x}{6 y} \cdot \frac{3}{10 y}$

Which expression is equivalent to the above product for all $y>0$ ?
A. $\frac{x}{2}$
B. $\frac{25 x}{9}$
C. $\frac{x}{2 y^{2}}$
D. $\frac{x}{4 y^{2}}$

Correct answer: D
level: 2
11. $\frac{3 g^{2}+12 g}{g+7} \cdot \frac{4}{8 g^{2}}$

Which expression is equivalent to the above product for all $g>0$ ?
A. $\frac{3 g+48}{g^{2}+56 g}$
B. $\frac{12 g+12}{8 g^{2}+7 g}$
C. $\frac{3 g+12}{2 g^{2}+14 g}$
D. $\frac{3 g+12}{2 g+14}$

Correct answer: C
level: 3
12. $\frac{4 y}{2 y^{2}+3 y-27}-\frac{y+1}{6 y^{2}+27 y}$

Which expression is equivalent to the above difference?
A. $\frac{11 y^{2}+2 y+3}{3 y(2 y+9)(y-3)}$
B. $\frac{11 y^{2}-2 y-3}{3 y(2 y+9)(y-3)}$
C. $\frac{10 y^{2}-5 y+3}{3 y(2 y-3)(y+9)}$
D. $\frac{10 y^{2}+5 y-3}{3 y(2 y-3)(y+9)}$
level: 3
13. $\frac{r^{2}+14 r+49}{r^{2}+15 r+56}$

Which expression is equivalent to the following expression, for all $r>0$ ?
A. $\frac{14 r+49}{15 r+56}$
B. $\frac{14+7}{15+8}$
C. $\frac{r+7}{r+8}$
D. $\frac{49}{r+56}$

Correct answer: C level: 3
14. $\frac{8 v}{28 w+21}-\frac{3 v+10}{4 w+3}$

Which expression is equivalent to the above difference?
A. $\frac{8 v^{2}-21 v+10}{24 w+18}$
B. $\frac{-13 v+10}{24 w+18}$
C. $\frac{53 v+10}{28 w+21}$
D. $\frac{-13 v-70}{28 w+21}$

Correct answer: D level: 3
15. $\frac{3 c^{2}-300}{5 c^{2}-52 c+20}$

Which expression is equivalent to the above expression, for all $\mathrm{c}<0 \mathrm{c}<0$ ?
A. $\frac{c+10}{5 c-2}$
B. $\frac{3 c+30}{5 c-2}$
C. $\frac{c-20}{5 c+4}$
D. $\frac{3 c-60}{5 c+4}$

Correct answer: B
level: 3
16. $\frac{2 n^{3} m}{5 l^{2}}-\frac{5 n^{3} m}{7 l^{2}}$

Which expression is equivalent to the above sum for all $\ell<-2$ ?
A. $\frac{7 n^{3} m}{35 l^{2}}$
B. $\frac{-3 n^{3} m}{35 l^{2}}$
C. $\frac{-11 n^{3} m}{35 l^{2}}$
D. $\frac{-10 n^{6} m^{2}}{35 l^{4}}$
17. $\frac{3.5}{3 p^{3}}+\frac{7}{4 p}$

Which expression is equivalent to the above sum for all $p>7$ ?
A. $\frac{24.5}{12 p^{4}}$
B. $\frac{21 p^{2}+14}{12 p^{3}}$
C. $\frac{21 p^{2}-14}{12 p^{3}}$
D. $\frac{10.5 p^{2}-28}{12 p^{3}}$

Correct answer: B
level: 3
18. $\frac{1}{3}-\frac{1}{2 u^{2}}+\frac{2}{u^{3}}$

Which expression is equivalent to the above sum for all $u<-5$ ?
A. $\frac{2}{3 u^{3}}$
B. $\frac{-2}{6 u^{5}}$
C. $\frac{2 u^{3}+9}{6 u^{3}}$
D. $\frac{2 u^{3}-3 u+12}{6 u^{3}}$

Correct answer: D
level: 3
19. $\frac{2.5 d r^{2}}{6}+\frac{3 d r^{2}}{4}$

Which expression is equivalent to the above sum?
A. $\frac{7 d r^{2}}{6}$
B. $\frac{7 d r^{2}}{12}$
C. $\frac{5.5 d r^{2}}{10}$
D. $\frac{5.5 d r^{2}}{12}$

Correct answer: A
level: 3
20. $2+\frac{4}{V}-\frac{3}{2 v^{2}}$

Which expression is equivalent to the above difference for all $v<0$ ?
A. $-\frac{12}{v^{3}}$
B. $\frac{2 v^{2}+2 v-3}{2 v^{2}}$
C. $\frac{4 v^{2}+8 v-3}{2 v^{2}}$
D. $\frac{4 v^{2}+8 v-3}{6 v^{2}}$ Correct answer: C level: 3
21. $\frac{\left(\frac{5^{5} n^{2}}{\left.l^{7}\right)}\right.}{\left(\frac{3^{3} n^{9}}{l n^{3}}\right)}$

Which expression is equivalent to the above quotient for all $\ell<-2$ and $n>4$ ?
A. 0
B. 1
C. $l^{4} n^{5}$
D. $\frac{1}{l^{4} n^{5}}$

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level: 3
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22. $\left(\frac{\pi a^{4}}{12 r^{3}}\right)\left(\frac{18 \pi a^{3} r^{2}}{5}\right)$

Which expression is equivalent to the above product for all $r>6$ ?
A. $\frac{3 \pi^{2} a^{7}}{10 r}$
B. $\frac{5 a}{216 r^{5}}$
C. $\frac{3 \pi^{2} a^{7}}{10}$
D. $\frac{21 r^{5}}{5 a}$

Correct answer: A
level: 3
23. $\frac{\left(\frac{10 p}{9 r^{5}}\right)}{\left(\frac{5 p^{7}}{3 r^{2}}\right)}$

Which expression is equivalent to the above quotient for all $p>2$ and $r<-2$ ?
A. $\frac{2}{3 r^{3} p^{6}}$
B. $\frac{2 p^{6}}{3 r^{3}}$
C. $\frac{3 r^{3} p^{6}}{2}$
D. $\frac{3 r^{3}}{2 p^{6}}$

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level: 3
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24. $\frac{-12 z^{3}+4 z^{2}}{4 z^{2}+16 z}$

Which expression is equivalent to the above expression, for all $z<-10$ ?
A. $\frac{-11 z}{4}$
B. $-3 z+\frac{z}{4}$
C. $\frac{-3 z^{2}+z}{z+4}$
D. $\frac{3 z^{2}-z}{z+4}$

Correct answer: C
level: 3
25. $\frac{\left(\frac{2 m c^{2}}{6 b}\right)}{\left(\frac{10 c^{4}}{3 b^{3}}\right)}$

Which expression is equivalent to the above quotient for all $b>0$ and $c>0$ ?
A. $\frac{m}{10}$
B. $\frac{m b^{2}}{10 c^{2}}$
C. $\frac{5 m c^{2}}{16 b^{2}}$
D. $\frac{10 m c^{6}}{9 b^{4}}$

Correct answer: B
level: 3
26. $\frac{a^{5} l^{2}}{3} \cdot \frac{b}{a^{2}}$

Which expression is equivalent to the above product for all $a>0$ ?
A. $\frac{b l^{2}}{3 a^{3}}$
B. $\frac{a^{7} l^{2}}{3 b}$
C. $\frac{b l^{2}}{3}$
D. $\frac{a^{3} b l^{2}}{3}$

Correct answer: D
level: 3
27. $\frac{3 x^{2}+x-2}{3 x^{2}-5 x+2}$

Which of the following is equivalent to the above expression for all $x>2$ ?
A. -1
B. $\frac{2}{3}$
C. $\frac{x+1}{x-1}$
D. $\frac{x-2}{2-5 x}$

Correct answer: C
level: 3
28. $\frac{4 l^{2}+4 l-3}{2 l^{2}-7 l-15}$

Which of the following is equivalent to the above expression for all $\ell>6$ ?
A. $\frac{3}{20}$
B. $-\frac{3}{20}$
C. $\frac{2 l+1}{l+5}$
D. $\frac{2 l-1}{l-5}$

Correct answer: D
level: 3
29. $\frac{2 p^{2}+8 p+6}{2 p^{2}+5 p+3}$

Which of the following is equivalent to the above expression for all $p<-3$ ?
A. $\frac{7}{4}$
B. $\frac{2 p+6}{2 p+3}$
C. $\frac{8 p+6}{5 p+3}$
D. $\frac{2 p+2}{p+1}$
30. $\frac{1.6 x y^{2}+0.8 y}{0.4 x y}$

Which of the following is equivalent to the above expression for all $y>6$ and $x>8$ ?
A. $\frac{3 y}{5}$
B. $\frac{2 x y+1}{4 x}$
C. $\frac{4 x y+2}{x}$
D. $4 y+2$

Correct answer: C level: 3
31. $\frac{x^{2}+6 x-27}{9-x^{2}}$

Which expression is equivalent to the above for all $x<0$ ?
A. $-\frac{x+9}{3+x}$
B. $-\frac{x-9}{x-3}$
C. $\frac{x+9}{3+x}$
D. $6 x-3$

Correct answer: A level: 3
32. $\frac{7 w-3}{21 w^{2}+5 w-6}$

Which expression is equivalent to the above for all $w>1$ ?
A. $\frac{7 w-3}{(7 w+6)(3 w-1)}$
B. $\frac{1}{3 w-2}$
C. $\frac{1}{3 w+2}$
D. $\frac{1}{5}$

Correct answer: C level: 3
33. $\frac{2 d^{2}-3 d}{16 d^{4}-81}$

Which expression is equivalent to the above for all $d>2$ ?
A. $\frac{d(2 d-3)}{\left(4 d^{2}-9\right)^{2}}$
B. $\frac{d}{(2 d-3)\left(4 d^{2}+9\right)}$
C. $\frac{d}{(2 d+3)\left(4 d^{2}-9\right)}$
D. $\frac{d}{(2 d+3)\left(4 d^{2}+9\right)}$
Correct answer: D
level: 3
34. $\frac{16 w^{2}+24 w z+9 z^{2}}{-4 w^{2}-3 w z}$

Which expression is equivalent to the above expression, given that $4 w+3 z \neq 0$ ?
A. $\frac{4 w+3 z}{w}$
B. $-\frac{4 w+3 z}{w}$
C. $\frac{4 w-3 z}{w}$
D. $-\frac{4 w-3 z}{w}$

Correct answer: B level: 3
35. $\frac{12 x-x^{2}}{x^{2}-10 x-24}$

Which expression is equivalent to the above for all $x<10$ ?
A. $-\frac{x}{x-2}$
B. $\frac{x}{x-2}$
C. $\frac{x}{x+2}$
D. $-\frac{x}{x+2}$

Correct answer: D
level: 3
36. $\frac{x^{2}+6 x-30}{30-6 x-x^{2}}$

Which expression is equivalent to the above for all $x^{2}+6 x-30 \neq 0$ ?
A. -1
B. 1
C. 0
D. $\frac{(x+6)(x-5)}{(6-x)(5+x)}$

Correct answer: A level: 3
37. $\frac{5 x^{2}-33 x-14}{x^{2}-7 x}$

Which expression is equivalent to the above for all $x<6$ ?
A. -26
B. $\frac{5 x-2}{-x}$
C. $\frac{5 x-2}{x}$
D. $\frac{5 x+2}{x}$

Correct answer: D level: 3
38. $\frac{a^{2}+18 a+81}{a-3} \cdot \frac{3-a}{(a+9)^{3}}$

Which expression is equivalent to the above product for all $a>4$ ?
A. $-\frac{1}{a+9}$
B. $-\frac{1}{a+9}$
C. $a+9$
D. -1

Correct answer: A
level: 3
39. $\frac{\left(\frac{x^{2}+3 x+2}{x+2}\right)}{\left(\frac{x^{2}+x}{x}\right)}$

Which expression is equivalent to the above quotient for all $x>0$ ?
A. $\frac{x}{x+1}$
B. $x$
C. 3
D. 1

Correct answer: D
level: 3
40. $\frac{\left(\frac{x^{2}-81}{9-x}\right)}{\left(\frac{18 x+2 x^{2}}{2 x}\right)}$

Which expression is equivalent to the above quotient for all $x>9$ ?
A. $-(x+9)^{2}$
B. $\frac{1}{2 x}$
C. -1
D. 1

Correct answer: C
level: 3
41. $\frac{7}{x-5}+\frac{4}{5-x}$

Which expression is equivalent to the above sum for all $x \neq 5$ ?
A. $\frac{11}{x-5}$
B. $\frac{11}{5-x}$
C. $\frac{3}{x-5}$
D. $\frac{3}{5-x}$

Correct answer: C
level: 3
42. $\frac{x^{2}}{x-2}+\frac{4}{2-x}$

Which of the following is equivalent to the expression shown above for $x \neq 2$ ?
A. $x+2$
B. $x-2$
C. $\frac{x^{2}-4}{2-x}$
D. $\frac{x^{2}+4}{x-2}$

Correct answer: A
level: 3
43. $\frac{x}{x^{2}+5 x-14}+\frac{7}{x^{2}+5 x-14}$

Which expression is equivalent to the above sum for all $x \geq 3$ ?
A. $\frac{x+7}{2 x^{2}+10 x-28}$
B. $\frac{7 x}{x^{2}+5 x-14}$
C. $\frac{1}{x-2}$
D. $\frac{1}{x+2}$

Correct answer: C level: 3
44. $\frac{3}{c+4}+\frac{1}{4}$

Which expression is equivalent to the above sum for $c \neq-4$ ?
A. 1
B. $\frac{4}{c+8}$
C. $\frac{c+16}{4 c+16}$
D. $\frac{c+16}{8 c+32}$

Correct answer: C
level: 3
45. $\frac{2 x}{x-3}-\frac{x+3}{x-3}$

Which expression is equivalent to the above sum for $x \neq 3$ ?
A. 1
B. $\frac{x+3}{x-3}$
C. $\frac{2 x}{x-3}-1$
D. $\frac{3 x+3}{x-3}$
Correct answer: A
level: 3
46. $\frac{2}{x^{2}+x}+\frac{4}{x^{2}+7 x+6}$

Which expression is equivalent to the above sum for all $x>0$ ?
A. $\frac{6}{2 x^{2}+8 x+6}$
B. $\frac{6 x+14}{x(x+7)(x+1)}$
C. $\frac{6 x+8}{\left(x^{2}-1\right)(x+6)}$
D. $\frac{6 x+12}{x^{3}+7 x^{2}+6 x}$

Correct answer: D level: 3
47. $\frac{\left(\frac{7 m^{2}+59 m+24}{m^{2}+4 m-5}\right)}{\left(\frac{m^{2}+4 m-32}{3 m+15}\right)}$

Which expression is equivalent to the above quotient for all $m>0$ ?
A. $\frac{7 m^{2}+59 m-8}{3 m+10}$
B. $\frac{-32\left(7 m^{2}+59 m+24\right)}{-15(m+5)}$
C. $\frac{21 m+9}{(m-1)(m-4)}$
D. $\frac{7 m+3}{(m-1)(m-4)}$

## Correct answer: C

## level: 4

48. $\frac{\left(\frac{-x^{2}-2 x+3}{x^{3}-3 x^{2}+2 x}\right)}{\left(\frac{3 x^{2}+24 x+45}{5 x^{2}+25 x}\right)}$

Which expression is equivalent to the above quotient for all $x>10$ ?
A. $\frac{-5}{3 x-6}$
B. $\frac{-5}{3 x+9}$
C. $\frac{-5 x^{2}+10 x+15}{3 x^{3}-21 x+18}$
D. $\frac{-3 x^{2}-18 x-27}{5 x^{3}-10 x^{2}}$

Correct answer: A
level: 4
49. $\frac{5 m}{m^{2}-24 m n+144 n^{2}}+\frac{2 n}{m^{2}-144 n^{2}}$

Which expression is equivalent to the above sum?
A. $\frac{5 m^{2}+60 m n+2 n^{2}}{(m-12 n)(m+12 n)}$
B. $\frac{5 m^{2}+62 m n-24 n^{2}}{(m-12 n)^{2}(m+12 n)}$
C. $\frac{5 m-24 m n+2 n}{(m-12 n)(m-12 n)}$
D. $\frac{5 m^{2}-58 m n+24 n^{2}}{(m-12 n)(m+12 n)^{2}}$
Correct answer: B
level: 4
50. $\frac{x^{2}+2 x-63}{x^{2}-49}$

Which expression is equivalent to the above for all $x<0$ ?
A. $\frac{x-9}{x-7}$
B. $\frac{x+9}{x+7}$
C. $\frac{2 x-63}{49}$
D. $\frac{2 x-63}{-49}$

Correct answer: B level: 4
51. $\frac{7}{x-1}+\frac{6}{x^{2}-12 x+11}$

Which expression is equivalent to the above sum?
A. $\frac{7 x+90}{(x-1)(x+12)}$
B. $\frac{7 x+18}{(x-1)(x+12)}$
C. $\frac{7 x-5}{(x-1)(x-11)}$
D. $\frac{7 x-71}{(x-1)(x-11)}$
Correct answer: D
level: 4
52. $\frac{3}{x^{2}-x-20}+\frac{1}{x^{2}+9 x+20}$

Which expression is equivalent to the above sum for all $x>5$ ?
A. $\frac{4}{2 x^{2}+8 x}$
B. $\frac{4 x+10}{\left(x^{2}-25\right)(x+4)}$
C. $\frac{4 x+10}{(x-5)^{2}(x+4)}$
D. $\frac{4 x+8}{\left(x^{2}-16\right)(x+5)}$
53. $\frac{2}{x^{2}-9}+\frac{1}{x^{2}+9 x+18}$

Which expression is equivalent to the above sum for all $x>-2$ ?
A. $\frac{3}{2 x^{2}+9 x+9}$
B. $\frac{2 x+13}{x^{2}+9 x+18}$
C. $\frac{3}{x^{2}+3 x-18}$
D. $\frac{3}{x^{2}+9 x+18}$

Correct answer: C
level: 4
54. $\frac{m}{m^{2}-25}+\frac{5}{25-m^{2}}$

Which expression is equivalent to the above sum for all $m<4$ ?
A. $m+5$
B. $\frac{m+5}{m^{2}-25}$
C. $-\frac{1}{m-5}$
D. $\frac{1}{m+5}$

Correct answer: D
level: 4
55. $\frac{\left(\frac{64-25 b^{2}}{\left.2 b+b^{2}\right)}\right.}{\left(\frac{25 b-40}{b+2}\right)}$

Which expression is equivalent to the above quotient for all $b>2$ ?
A. $-\frac{8+5 b}{5 b}$
B. $\frac{8+5 b}{5 b}$
C. $-\frac{5(8-5 b)^{3}}{b(b+2)^{2}}$
D. -8
Correct answer: A
level: 4
56. $\frac{c^{4}-81}{c+3} \cdot \frac{c+2}{c^{2}-c-6}$

Which expression is equivalent to the above product for all $c>4$ ?
A. $\frac{\left(c^{2}+9\right)^{2}}{c^{2}-9}$
B. $\frac{c^{5}-162}{c^{3}-c-18}$
C. $c^{2}-9$
D. $c^{2}+9$

Correct answer: D level: 4
57. $\frac{x^{2}-2 x y+y^{2}}{16-y^{2}} \cdot \frac{8 y-32}{4 x-4 y}$

Which expression is equivalent to the above product for all $y>5$ and $x \neq y$ ?
A. $\frac{2}{y-4}$
B. $-\frac{2}{4+y}$
C. $\frac{2 x-2 y}{y-4}$
D. $-\frac{2 x-2 y}{4+y}$

Correct answer: D
level: 4
58. $\frac{12 x^{2}-13 x-4}{16 x+4} \cdot \frac{4 x+20}{9 x^{2}-16}$

Which expression is equivalent to the above product for all $x>2$ ?
A. $\frac{x+5}{3 x+4}$
B. $\frac{x+5}{3 x-4}$
C. $\frac{4 x+20}{3 x+4}$
D. $\frac{19 x}{13}$

$$
\text { Correct answer: A level: } 4
$$

59. $\frac{\left(\frac{3 x^{2}-2 x-5}{3 x^{2}+x}\right)}{\left(\frac{15-9 x}{3 x}\right)}$

Which expression is equivalent to the above quotient for all $x<-2$ ?
A. 1
B. -1
C. $\frac{(3 x-5)(5-3 x)}{x^{2}}$
D. $-\frac{x-1}{x+1}$
Correct answer: B
level: 4
60. $\frac{2.5 m^{2}-10}{2.5 m^{2}-10 m+10}$

Which expression is equivalent to the above expression, for all $m<0$ ?
A. $\frac{m+2}{m-2}$
B. $\frac{m-2}{m+2}$
C. $\mathrm{m}+2$
D. $\frac{1}{m-2}$

Correct answer: A
level: 4

## Operations with polynomials

1. $\left(6 t^{4}-t+1\right)-\left(6 t^{3}-4 t\right)$

Which of the following expressions is equivalent to the above expression?
A. $6 t^{4}-6 t^{3}+3 t+1$
B. $6 t^{4}-6 t^{3}-5 t+1$
C. $3 \mathrm{t}+1$
D. $-5 \mathrm{t}+1$

Correct Answer: A Difficult Level: 3
2. Which of the following expressions is equivalent to the product of $\left(f^{2}-2\right)$ and ( $\left.f^{7}+2 f^{5}+4 f^{3}+8 f\right)$ ?
A. $\mathrm{f}\left(-2 f^{8}-2 f^{6}-4 f^{4}-8 f^{2}-16\right)$
B. $\mathrm{f}\left(-2 f^{8}-4 f^{6}-8 f^{4}-16 f^{2}\right)$
C. $\mathrm{f}\left(f^{13}+2 f^{9}-2 f^{6}+4 f^{5}-4 f^{4}-8 f^{2}+8 f-16\right)$
D. $\mathrm{f}\left(f^{8}-16\right)$

Correct Answer: D Difficult Level: 3
3. $\mathrm{P}(\mathrm{x})=3 x^{2}+4 x-5$ and $Q(x)=7 x^{3}-2 x-5$

Which of the following expressions is equivalent to $\mathrm{P}(\mathrm{x})-\mathrm{Q}(\mathrm{x})$ ?
A. $-7 x^{3}+3 x^{2}+6 x$
B. $-7 x^{3}+3 x^{2}+6 x-10$
C. $-4 x^{2}+6 x$
D. $-4 x^{2}+6 x-10$

Correct Answer: A Difficult Level: 3
4. Let $\alpha(u)=\left(u+2 u^{2}+3 u^{3}\right)$ and $\beta(u)=(1+u)$. Which of the following expressions is equivalent to $\alpha(u) \cdot \beta(u)$ ?
A. $u+2 u^{2}+5 u^{3}+3 u^{4}$
B. $1+2 u+2 u^{2}+3 u^{3}$
C. $u+5 u^{6}+7 u^{8}$
D. $1+3 u^{3}+4 u^{4}$

Correct Answer: A Difficult Level: 3
5. $(-5 \mathrm{z})-(2-\mathrm{z}) \cdot(3-\mathrm{z})$

Which of the following expressions is equivalent to the above expression?
A. $-z^{2}-10 z-6$
B. $-z^{2}-4 z+6$
C. $-z^{2}-6$
D. $z^{2}-10 z-6$

Correct Answer: C Difficult Level: 3
6. $(S-2)+\left(\frac{7}{3} S^{3}+\frac{7}{3} S^{2}-7 S+\frac{4}{3}\right)$

Which of the following expressions is equivalent to the above expression?
A. $\frac{1}{3}\left(7 s^{3}+7 s^{2}-18 s-2\right)$
B. $\frac{1}{3}(7 s 3+7 s 2-6 s-2)$
C. $\frac{1}{3}\left(7 s^{3}+7 s^{2}-18 s+2\right)$
D. $\frac{1}{3}(7 s 3+7 s 2-6 s+2)$

Correct Answer: A Difficult Level: 4
7. $\left(-2 j^{2}\right) \cdot \frac{1}{4}+\left(\frac{1}{2} j^{2}-1\right)$

Which of the following expressions is equivalent to the above expression?
A. -1
B. $\frac{3}{8} j^{2}-1$
C. $\left(\frac{1}{2} j+1\right)\left(\frac{1}{2} j-1\right)$
D. $(\mathrm{j}+1)(\mathrm{j}-1)$

Correct Answer: A Difficult Level: 4
8. What is the product of $(1-p)$ and $\left(\frac{1}{2}-p\right)$, all reduced by $p$ ?
A. $\frac{1}{2}\left(1-5 p+2 p^{2}\right)$
B. $\frac{1}{2}\left(2-5 p+2 p^{2}\right)$
C. $\frac{1}{2}\left(1-3 p+2 p^{2}\right)$
D. $\frac{1}{2}\left(2-3 p+2 p^{2}\right)$

Correct Answer: A Difficult Level: 4
9. What is the sum of $\left(w^{6}+\frac{2}{3} w^{2}\right)$ and $\left(\frac{1}{2} w^{6}+\frac{1}{3} w^{2}+\frac{1}{4}\right)$ ?
A. $\left(\frac{1}{2} w^{6}+\frac{1}{3} w^{2}-\frac{1}{4}\right)$
B. $\left(\frac{1}{2} w^{6}+w^{2}+\frac{1}{4}\right)$
C. $\left(\frac{3}{2} W^{6}+\frac{1}{3} W^{2}-\frac{1}{4}\right)$
D. $\left(\frac{3}{2} W^{6}+w^{2}+\frac{1}{4}\right)$

Correct Answer: D Difficult Level: 4
10. $f(x)=\left(\frac{1}{2} x-1\right) \quad g(x)=\left(x^{3}+2 x^{2}+4 x+8\right)$

Which of the following expressions is equivalent to $f(x) g(x)$ ?
A. $\frac{1}{2} \mathrm{x}^{4}-8$
B. $\frac{1}{2} x^{4}+x^{3}+2 x^{2}+4 x-8$
C. $-\frac{1}{2} x^{4}-x^{2}-2 x-4$
D. $-\frac{1}{2} x^{4}+x^{2}+2 x-4$

Correct Answer: A Difficult Level: 4
11. $2 x(x-2)+3\left(4-x^{2}\right)$

Which of the following is equivalent to the above expression?
A. $(6+x)(2-x)$
B. $(x-6)(x+2)$
C. $x^{2}+10$
D. $x^{2}-4 x+12$

Correct Answer: A Difficult Level: 4
12. $(3 y-2)(y+a)=3 y^{2}+b y-24$

If the above equation is true for all values of $y$, where $a$ and $b$ are constants, which of the following is the value of $b$ ?
A. -38
B. 12
C. 34
D. 36

Correct Answer: C Difficult Level: 4
13. Which of the following is the product of $\mathrm{W}+2$, $2 w-5, w+2,2 w-5$, and $3 w+43 w+4$ ?
A. $6 w^{3}-40$
B. $6 w^{3}+40$
C. $6 w^{3}+5 w^{2}-34 w-40$
D. $6 w^{3}+11 w^{2}-26 w-40$

Correct Answer: C Difficult Level: 4
14. $P(x)=g^{2}+10 g+25$ and $\mathrm{Q}(\mathrm{x})=\mathrm{g}+5$. What is $P(x) \quad Q(x)$ ?
A. $\left(\mathrm{g}^{3}+5\right)^{2}$
B. $\left(g^{2}+5\right)^{2}$
C. $(\mathrm{g}+5)^{2}$
D. $(\mathrm{g}+5)^{3}$

Correct Answer: D Difficult Level: 4
15. $4-4 \mathrm{a}-(5+\mathrm{a})(5-\mathrm{a})$

Which of the following expressions is equivalent to the above?
A. $(a-7)(-a+3)(a-7)(-a+3)$
B. $(-a+7)(a+3)(-a+7)(a+3)$
C. $(a-7)(a+3)(a-7)(a+3)$
D. $(a+7)(a-3)(a+7)(a-3)$

Correct Answer: C Difficult Level: 4
16. $\left(-1-5 n+\mathrm{an}^{2}\right)-\left(7 \mathrm{n}-4 \mathrm{n}^{2}+9\right)=12 \mathrm{n}^{2}-12 \mathrm{n}-10$

If the equation above is true for all values of $n$, then which of the following is the value of a?
A. 8
B. 12
C. 16
D. 19

Correct Answer: A Difficult Level: 3
17. Which of the following is equivalent to 18 more than the product of $9-6$ p and $\mathrm{p}-2$ ?
A. $3(7 \mathrm{p}+6)$
B. $-3 p(2 p-7)$
C. $(27-6 p)(p-2)$
D. $(9-6 p)(p+16)$

Correct Answer: B Difficult Level: 3
18. $(8 c+5)^{3}$. Which of the following is equivalent to the above expression?
A. $512 \mathrm{c}^{2}+125$
B. $(8 \mathrm{c}+5)(64 \mathrm{c} 2-40 \mathrm{c}+25)$
C. $128 c^{3}+1040 c^{2}+220 c+625$
D. $512 \mathrm{c}^{3}+960 \mathrm{c}^{2}+600+125$

Correct Answer: D Difficult Level: 3
19. $\mathrm{b}\left(-\frac{2}{3} b+1\right)+6\left(\frac{1}{9} \mathrm{~b}^{2}-21\right)$

Which of the following expressions is equivalent to the above expression?
A. b-20
B. b-126
C. $\left(-\frac{2}{3} b^{2}+7\right)\left(\frac{1}{9} b^{2}-21\right)$
D. $(b+6)\left(\frac{1}{9} b^{2}-\frac{2}{3} b-20\right)$

Correct Answer: B Difficult Level: 3
20. $Q(t)=2-0.3 t+0.8 t^{2}$ and $R(t)=1.5 t^{2}+0.7 t-6.3$

Which of the following is equivalent to $\mathrm{R}(\mathrm{t})-\mathrm{Q}(\mathrm{t})$ ?
A. $-0.7 \mathrm{t}^{2}-\mathrm{t}+8.3$
B. $-0.5 \mathrm{t}^{2}+\mathrm{t}-7.1$
C. $0.7 \mathrm{t}^{2}+0.4 \mathrm{t}-4.3$
D. $0.7 \mathrm{t}^{2}+\mathrm{t}-8.3$

Correct Answer: D Difficult Level: 3
21. What is the sum of $3 \mathrm{~b}(\mathrm{~b}-4) 3 b(b-4)$ and $6(\mathrm{~b}-8) 6(b-8)$ ?
A. 3 b (1-2b-16)
B. 3 b (b-2-16)
C. $3\left(b^{2}-2 b-16\right)$
D. $3\left(b^{2}-2-16 b\right)$

Correct Answer: C Difficult Level: 2
22. Which of the following expressions is equivalent to:
$\left(4 X^{3}-5 X\right)+\left(8 X-3 X^{3}\right)$
A. $x^{3}+3 x$
B. $x^{3}-3 x$
C. $7 x^{3}-3 x$
D. $7 x^{3}+3 x$

Correct Answer: A Difficult Level: 2
23. Which of the following expressions is equivalent to $\left(3 c-4 c^{2}+c^{3}\right)-\left(5 c^{2}+8 c^{3}-6 c\right)$
A. $7 c^{3}+9 c^{2}-3 c$
B. $7 c^{3}+c^{2}-3 c$
C. $-7 c^{3}+c^{2}+9 c$
D. $-7 c^{3}-9 c^{2}+9 c$

Correct Answer: D Difficult Level: 2
24. Which of the following is equivalent to $\left(8 r^{4}+4 r^{2}+2 r\right)-\left(8 r^{4}+4 r^{2}+1\right)\left(8 r^{4}+4 r^{2}\right.$ $+2 r)-\left(8 r^{4}+4 r^{2}+1\right)$ ?
A. $8 r^{2}+2 r+1$
B. $8 r^{2}+3 r$
C. $2 \mathrm{r}-1$
D. r

Correct Answer: C Difficult Level: 2
25. What is the product of $(x+6)$ and $(x+1)$ ?
A. $x^{2}+7 x+6$
B. $x^{2}+6 x+7$
C. $8 x+6$
D. $7 \mathrm{x}+7$

Correct Answer: A Difficult Level: 2

## Polynomial factors and graphs

1. $P(x)=2 x^{3}-18 x$

Given the polynomial function $P$ defined above, what are its zeros?
A. $\{-9,-6,2,3\}$
B. $\{-9,0,2\}$
C. $\{-3,3\}$
D. $\{-3,0,3\}$

Correct Answer: D Difficult Level: 2
2. Which of the following functions could represent the graph BELOW in the $x y$-plane, where $y=P(x)$ ?

A. $P(x)=x^{2}+6 x+8$
B. $P(x)=x^{3}+6 x^{2}+8 x$
C. $P(x)=x^{2}-6 x+8$
D. $P(x)=x^{3}-6 x^{2}+8 x$

Correct Answer: B Difficult Level: 2
3. A polynomial has zeros at $-9,2$, and 0 . Which of the following could be the polynomial?
A. $x^{2}-7 x-18$
B. $x^{3}+7 x^{2}-18 x$
C. $x^{3}+7 x^{2}-18 x$
D. $x^{3}+6 x^{2}-25 x+18$

Correct Answer: B Difficult Level: 2
4. $(x-7)(x+5)(2 x-3)$

Given the polynomial above, what are its zeros?
A. $\{-7,5,-3\}$
B. $\{7,-5,3\}$
C. $\left\{-7,5,-\frac{3}{2}\right\}$
D. $\left\{7,-5, \frac{3}{2}\right\}$

Correct Answer: D Difficult Level: 2
5. $2(x+55)(x-17)$

Given the polynomial above, what are its zeros?
A. $x=-55$ and $x=17$
B. $x=-55, x=-2$, and $x=17$
C. $x=-17$ and $x=55$
D. $x=-17, x=2$, and $x=55$

Correct Answer: A Difficult Level: 2
6. $G(z)=(z-1)^{5}-(z-1)^{4}$ The polynomial function $G$ is defined above. What is the product of the zeros of $G$ ? Fill in the blank:
Correct Answer: 2 Difficult Level: 2
7. The polynomial function $P$ has zeros at 3 and 6 . Which of the following could be the definition of $P$ ?
A. $P(x)=x^{2}+9 x+18$
B. $P(x)=x^{2}-9 x+18$
C. $P(x)=x^{2}+3 x+6$
D. $P(x)=x^{2}+6 x+3$

Correct Answer: B Difficult Level: 2
8. Which of the following equations could represent the graph below in the $x y$-plane?
I. $y=(x-3)(x+3)$
II. $y=(x-4)^{2}$
III. $y=(x+2)(x+7)$

A. I only
B. II only
C. I and III only
D. I, II and III

Correct Answer: A Difficult Level: 2
9. $h(t)=(t-8)^{1}(t-4)^{2}(t-2)^{3}(t-1)^{4}$

The polynomial function $h$ is defined above. How many distinct zeros does $h$ have?


Correct Answer: 4 Difficult Level: 2
10. $x^{3}+25 x^{2}+50 x-1000$

The polynomial above has $(x-5)$ and $(x+10)$ as factors. What is the remaining factor?
A. $(x+2)$
B. $(x-2)$
C. $(x+2)$
D. $(x-20)$

Correct Answer: C Difficult Level: 2
11. $x^{3}+7 x^{2}-36$

The polynomial above has zeros at -6 and 2. If the remaining zero is $z$, then what is the value of $-z$ ?
Correct Answer: 3 Difficult Level: 3
12. The function $p$ is a polynomial of $t$ such that $(t-10),(22-t),(t+10)$, and $(20+t)$ are all factors of $p(t)$. Which of the following could be the graph of $y=p(t)$ in the $t y$-plane?

A.

B.

D.
13. Which of the following graphs appears to represent a polynomial function with a double zero?
A.

B.

D.


Correct Answer: D Difficult Level: 3
14. $g(x)=x^{4}-4 x^{3}+6 x^{2}-4 x+1$

The function $g$ is defined above. Given that all zeros of $g$ are integers between
-1 and linclusive, how many distinct zeros does $g$ have?
Correct Answer: 1 Difficult Level: 3
15. $x^{2}-a x+24$

If one of the zeros of the polynomial above is 8 , what is the other zero? $\qquad$
Correct Answer: 3 Difficult Level: 3
16. For a function $g$, the graph of $\mathrm{y}=\mathrm{g}(\mathrm{x}) y=g(x)$ is shown BELOW. When $g(x)$ is divided by $(x+10)$, the remainder is -20 . Which of the following is closest to the remainder when $g(x)$ is divided by $(x-10)$ ?

A. -28
B. -2
C. 2
D. 28

Correct Answer: C Difficult Level: 3
17. The polynomial function $f$ is defined as $f(c)=(c-k)\left(c^{2}-4 c+4\right)$ where $k$ is a constant. The value 2 is a zero of $f$. What is the remainder of $f(c)$ when divided by $(c-2)$ ?
$\square$
Correct Answer: 0 Difficult Level: 3
18. Which of the following graphs in the $x y$-plane have -3 and 5 as all of their distinct zeros for $-6 \leq x \leq 6$ ?


I.
II.

III.
A. I only
B. I and II only
C. II and III only
D. I. II and III.

Correct Answer: B Difficult Level: 3
19. Given some rational constant $a$, which polynomial equation could represent the graph BELOW in the $x y$-plane?

A. $y=a(x+1)^{2}(x-5)$
B. $y=a(x+1)(x-5)$
C. $y=a(x+1)(2 x+1)(x-5)$
D. $y=a(x-1)(x+5)^{2}$

Correct Answer: B Difficult Level: 3
20. The equation $s=(t+3)^{2}(t+2)(t+1)(t)(t-1)$ is graphed on the $s t$-plane. What is the product of the $t$-intercepts of the graph?
$\square$
Correct Answer: 0 Difficult Level: 3
21. $q(v)=(v-8)(v-5)(v-4)(v+5)(v+10)$

The function $q$ is defined above. If the sum of the zeros of $q$ is $s$, what is the value of $s$ ?

Correct Answer: 2 Difficult Level: 3
22. $(x-\sqrt{ } 3)^{2}(x-\sqrt{ } 7)$

Given the polynomial above, what are its zeros?
A. $x=-\sqrt{3}$ and $x=-\sqrt{7}$
B. $x=\sqrt{ } 3$ and $x=\sqrt{ } 7$
C. $x=3$ and $x=\sqrt{ } 7$
D. $x=-3$ and $x=-\sqrt{7}$

Correct Answer: B Difficult Level: 3
23. The graph of the polynomial equation $y=\alpha(t)$ is shown BELOW. Which of the following must be true?

A.The leading coefficient is positive.
B.The sum of the distinct t intercepts is negative.
C.The constant coefficient is positive.
D.The product of the distinct t intercepts is negative.

Correct Answer: D Difficult Level: 3
24. The graph shown at left could represent which of the following equations?

A. $h=-(b-10)(b-20)(b+20)$
B. $\mathrm{h}=(\mathrm{b}-10)(\mathrm{b}-20)(\mathrm{b}+20)$
C. $h=-(b+10)(b-20)(b+20)$
D. $h=(b+10)(b-20)(b+20)$

Correct Answer: A Difficult Level: 3
25. $x^{3}+7 x^{2}-36$

The polynomial above has zeros at -6 and 2 . If the remaining zero is $z$, then what is the value of $-z$ ?
Correct Answer: 3 Difficult Level: 3
26. The polynomial function $f$ is defined as $f(m)=(m 3-m 2-17 m-15)(m+1)$. When $f(m)$ is divided by $(m+1)$, what is the remainder?


Correct Answer: 0 Difficult Level: 4
27. $p(n)=\left(n^{3}-12 n^{2}+47 n-60\right)(n-4)$
$q(n)=(n+13)(n-4)$
The functions $p$ and $q$ are defined above. One of the functions has a zero at $n=5$. What
is $\quad(p+q)(5)$ ? $\square$
Correct Answer: 18 Difficult Level: 4
28. Which of the following could be the equation corresponding to the graph BELOW?

A. $s=a \cdot a \cdot a \cdot a$
B. $s=(a-1)(a-1)$
C. $s=a \cdot a \cdot a \cdot a \cdot a$
D. $s=(a-1)(a-1)(a-1)$

Correct Answer: C Difficult Level: 4
29. $p=(w-30)(w 2+178 w+7921)$

Given that -89 is a double zero of the polynomial equation above, which of the following could be the graph of the equation in the $p w$-plane?
A.

B.


C.

D.
$30 . \ell(x)=x^{4}+36 x^{2}-10,000$
The polynomial function $\ell$ is defined above. What is the remainder of $\ell(x)$ when divided by $(x+10)$ ?


Correct Answer: 3600 Difficult Level: 4
31. $g(w)=(w+13)^{3}(w+19)^{2}$

The polynomial function $g$ is defined above. When $g(w)$ is divided by $(w+16)$, the remainder is $r$. What is the value of $|r|$ ?


Correct Answer: 243 Difficult Level: 4
32. A function $\mathrm{p} p$ is defined as $p(x)=(x-a)(x-15)(x-20)+15$ where $a$ is a constant. Given that $p(7)=15$, what is the value of $a$ ?


Correct Answer: 7 Difficult Level: 4
33. A function $w$ is a defined as $w(x)=a x 2+b x+c$ where $a, b$, and $c$ are constants.

If $a=3$ and $w(3)=w(15)=0$, then what is the absolute value of $b$ ?


Correct Answer: 54 Difficult Level: 4
34. A function $s$ is defined as $s(x)=(x-4)(x-5)^{2}$. A function $h$ is defined as $h(x)=(x-a) s(x)$. For some constant $a,(x-a)^{3}$ is a factor of $h$. What is $s(a)$ ?
$\square$
Correct Answer: 0 Difficult Level: 4
35. $12 x^{2}+a x+2$

If one of the zeros of the above polynomial is $\frac{2}{3}$, what is the other zero?


Correct Answer: $\frac{1}{4}$ Difficult Level: 4
36.For any polynomial function $h$, the polynomial function $g$ is defined to be $g(w)=(w-25)(w-1) h(w)$. If $h$ has zeros at 1 and 3 only, what is the sum of the distinct zeros of $g$ ?


Correct Answer: 36 Difficult Level: 4
37. The polynomial function ff is defined as $f(x)=(x-c 1)(x-c 2)(x-c 3)(x-c n)$ for some positive integer $n$. Each of the values $c 1, c 2, c 3,,, c n$ is a real number. The graph of $y=f(x)$ is shown BELOW. Which of the following could be the value of $n$ ?

A. 0
B. 1
C. 2
D. 3

## Correct Answer: D Difficult Level: 4

38. The polynomial function $f$ is defined as $f(m)=(m 3-m 2-17 m-15)(m+1)$. When $f(m)$ is divided by $(m+1)$, what is the remainder?

Correct Answer: 0 Difficult Level: 4

## Polynomial factors and graphs

1. $P(x)=2 x^{3}-18 x$

Given the polynomial function $P$ defined above, what are its zeros?
A. $\{-9,-6,2,3\}$
B. $\{-9,0,2\}$
C. $\{-3,3\}$
D. $\{-3,0,3\}$

Correct Answer: D Difficult Level: 2
2. Which of the following functions could represent the graph BELOW in the $x y$-plane, where $y=P(x)$ ?

A. $P(x)=x^{2}+6 x+8$
B. $P(x)=x^{3}+6 x^{2}+8 x$
C. $P(x)=x^{2}-6 x+8$
D. $P(x)=x^{3}-6 x^{2}+8 x$

Correct Answer: B Difficult Level: 2
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A. $x^{2}-7 x-18$
B. $x^{3}+7 x^{2}-18 x$
C. $x^{3}+7 x^{2}-18 x$
D. $x^{3}+6 x^{2}-25 x+18$

Correct Answer: B Difficult Level: 2
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Given the polynomial above, what are its zeros?
A. $\{-7,5,-3\}$
B. $\{7,-5,3\}$
C. $\left\{-7,5,-\frac{3}{2}\right\}$
D. $\left\{7,-5, \frac{3}{2}\right\}$

Correct Answer: D Difficult Level: 2
5. $2(x+55)(x-17)$

Given the polynomial above, what are its zeros?
A. $x=-55$ and $x=17$
B. $x=-55, x=-2$, and $x=17$
C. $x=-17$ and $x=55$
D. $x=-17, x=2$, and $x=55$

Correct Answer: A Difficult Level: 2
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C. $P(x)=x^{2}+3 x+6$
D. $P(x)=x^{2}+6 x+3$

Correct Answer: B Difficult Level: 2
8. Which of the following equations could represent the graph below in the $x y$-plane?
I. $y=(x-3)(x+3)$
II. $y=(x-4)^{2}$
III. $y=(x+2)(x+7)$

A. I only
B. II only
C. I and III only
D. I, II and III

Correct Answer: A Difficult Level: 2
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The polynomial function $h$ is defined above. How many distinct zeros does $h$ have?


Correct Answer: 4 Difficult Level: 2
10. $x^{3}+25 x^{2}+50 x-1000$

The polynomial above has $(x-5)$ and $(x+10)$ as factors. What is the remaining factor?
A. $(x+2)$
B. $(x-2)$
C. $(x+2)$
D. $(x-20)$

Correct Answer: C Difficult Level: 2
11. $x^{3}+7 x^{2}-36$

The polynomial above has zeros at -6 and 2. If the remaining zero is $z$, then what is the value of $-z$ ?
Correct Answer: 3 Difficult Level: 3
12. The function $p$ is a polynomial of $t$ such that $(t-10),(22-t),(t+10)$, and $(20+t)$ are all factors of $p(t)$. Which of the following could be the graph of $y=p(t)$ in the $t y$-plane?

A.

B.

D.
13. Which of the following graphs appears to represent a polynomial function with a double zero?
A.

B.

D.


Correct Answer: D Difficult Level: 3
14. $g(x)=x^{4}-4 x^{3}+6 x^{2}-4 x+1$

The function $g$ is defined above. Given that all zeros of $g$ are integers between
-1 and linclusive, how many distinct zeros does $g$ have?
Correct Answer: 1 Difficult Level: 3
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A. -28
B. -2
C. 2
D. 28

Correct Answer: C Difficult Level: 3
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$\square$
Correct Answer: 0 Difficult Level: 3
18. Which of the following graphs in the $x y$-plane have -3 and 5 as all of their distinct zeros for $-6 \leq x \leq 6$ ?


I.
II.

III.
A. I only
B. I and II only
C. II and III only
D. I. II and III.

Correct Answer: B Difficult Level: 3
19. Given some rational constant $a$, which polynomial equation could represent the graph BELOW in the $x y$-plane?

A. $y=a(x+1)^{2}(x-5)$
B. $y=a(x+1)(x-5)$
C. $y=a(x+1)(2 x+1)(x-5)$
D. $y=a(x-1)(x+5)^{2}$

Correct Answer: B Difficult Level: 3
20. The equation $s=(t+3)^{2}(t+2)(t+1)(t)(t-1)$ is graphed on the $s t$-plane. What is the product of the $t$-intercepts of the graph?
$\square$
Correct Answer: 0 Difficult Level: 3
21. $q(v)=(v-8)(v-5)(v-4)(v+5)(v+10)$

The function $q$ is defined above. If the sum of the zeros of $q$ is $s$, what is the value of $s$ ?

Correct Answer: 2 Difficult Level: 3
22. $(x-\sqrt{ } 3)^{2}(x-\sqrt{ } 7)$

Given the polynomial above, what are its zeros?
A. $x=-\sqrt{3}$ and $x=-\sqrt{7}$
B. $x=\sqrt{ } 3$ and $x=\sqrt{ } 7$
C. $x=3$ and $x=\sqrt{ } 7$
D. $x=-3$ and $x=-\sqrt{7}$

Correct Answer: B Difficult Level: 3
23. The graph of the polynomial equation $y=\alpha(t)$ is shown BELOW. Which of the following must be true?

A.The leading coefficient is positive.
B.The sum of the distinct t intercepts is negative.
C.The constant coefficient is positive.
D.The product of the distinct t intercepts is negative.

Correct Answer: D Difficult Level: 3
24. The graph shown at left could represent which of the following equations?

A. $h=-(b-10)(b-20)(b+20)$
B. $\mathrm{h}=(\mathrm{b}-10)(\mathrm{b}-20)(\mathrm{b}+20)$
C. $h=-(b+10)(b-20)(b+20)$
D. $h=(b+10)(b-20)(b+20)$

Correct Answer: A Difficult Level: 3
25. $x^{3}+7 x^{2}-36$

The polynomial above has zeros at -6 and 2 . If the remaining zero is $z$, then what is the value of $-z$ ?
Correct Answer: 3 Difficult Level: 3
26. The polynomial function $f$ is defined as $f(m)=(m 3-m 2-17 m-15)(m+1)$. When $f(m)$ is divided by $(m+1)$, what is the remainder?


Correct Answer: 0 Difficult Level: 4
27. $p(n)=\left(n^{3}-12 n^{2}+47 n-60\right)(n-4)$
$q(n)=(n+13)(n-4)$
The functions $p$ and $q$ are defined above. One of the functions has a zero at $n=5$. What
is $\quad(p+q)(5)$ ? $\square$
Correct Answer: 18 Difficult Level: 4
28. Which of the following could be the equation corresponding to the graph BELOW?

A. $s=a \cdot a \cdot a \cdot a$
B. $s=(a-1)(a-1)$
C. $s=a \cdot a \cdot a \cdot a \cdot a$
D. $s=(a-1)(a-1)(a-1)$

Correct Answer: C Difficult Level: 4
29. $p=(w-30)(w 2+178 w+7921)$

Given that -89 is a double zero of the polynomial equation above, which of the following could be the graph of the equation in the $p w$-plane?
A.

B.


C.

D.
$30 . \ell(x)=x^{4}+36 x^{2}-10,000$
The polynomial function $\ell$ is defined above. What is the remainder of $\ell(x)$ when divided by $(x+10)$ ?


Correct Answer: 3600 Difficult Level: 4
31. $g(w)=(w+13)^{3}(w+19)^{2}$

The polynomial function $g$ is defined above. When $g(w)$ is divided by $(w+16)$, the remainder is $r$. What is the value of $|r|$ ?


Correct Answer: 243 Difficult Level: 4
32. A function $\mathrm{p} p$ is defined as $p(x)=(x-a)(x-15)(x-20)+15$ where $a$ is a constant. Given that $p(7)=15$, what is the value of $a$ ?


Correct Answer: 7 Difficult Level: 4
33. A function $w$ is a defined as $w(x)=a x 2+b x+c$ where $a, b$, and $c$ are constants.

If $a=3$ and $w(3)=w(15)=0$, then what is the absolute value of $b$ ?


Correct Answer: 54 Difficult Level: 4
34. A function $s$ is defined as $s(x)=(x-4)(x-5)^{2}$. A function $h$ is defined as $h(x)=(x-a) s(x)$. For some constant $a,(x-a)^{3}$ is a factor of $h$. What is $s(a)$ ?
$\square$
Correct Answer: 0 Difficult Level: 4
35. $12 x^{2}+a x+2$

If one of the zeros of the above polynomial is $\frac{2}{3}$, what is the other zero?


Correct Answer: $\frac{1}{4}$ Difficult Level: 4
36.For any polynomial function $h$, the polynomial function $g$ is defined to be $g(w)=(w-25)(w-1) h(w)$. If $h$ has zeros at 1 and 3 only, what is the sum of the distinct zeros of $g$ ?


Correct Answer: 36 Difficult Level: 4
37. The polynomial function ff is defined as $f(x)=(x-c 1)(x-c 2)(x-c 3)(x-c n)$ for some positive integer $n$. Each of the values $c 1, c 2, c 3,,, c n$ is a real number. The graph of $y=f(x)$ is shown BELOW. Which of the following could be the value of $n$ ?

A. 0
B. 1
C. 2
D. 3

## Correct Answer: D Difficult Level: 4

38. The polynomial function $f$ is defined as $f(m)=(m 3-m 2-17 m-15)(m+1)$. When $f(m)$ is divided by $(m+1)$, what is the remainder?

Correct Answer: 0 Difficult Level: 4

## Nonlinear equation graphs

1. The equations $\mathrm{y}=\frac{3}{x+4}$ and $\mathrm{y}=\frac{3}{x+4}-3$ are graphed in the $x y$-plane. Which of the following must be true of the asymptotes of the graphs of the two equations?
A. Both graphs have a vertical asymptote at $x=4$.
B. Both graphs have a vertical asymptote at $x=-4$.
C. $\mathrm{y}=\frac{3}{x+4}$ has a horizontal asymptote at $\mathrm{y}=0$, and $\mathrm{y}=\frac{3}{x+4}-3$ has a horizontal asymptote at $\mathrm{y}=3$
D. $\mathrm{y}=\frac{3}{x+4}$ has a vertical asymptote at $\mathrm{x}=0$, and $\mathrm{y}=\frac{3}{x+4}-3$ has a vertical asymptote at $\mathrm{x}=-3$.
Correct Answer: B Difficult Level: 2
2. The system of equations represented by the graph below is:
$y=x^{2} \quad y=-x^{2}+2 \quad y=x+2$
Which of the following lists all solutions to the system of equations?

A. $(-1,1)$
B. $(0,2)$
C. $(0,2)$ and $(2,4)$
D. $(-1,-1),(0,2),(1,1)$, and $(2,4)$

Correct Answer: A Difficult Level: 2
3. $y=2^{x-1} \quad x^{2}+y^{2}=25$

A system of two equations and their graphs in the $x y$-plane are shown BELOW. Which of the following ordered pairs is part of the solution set of the system of equations?

A. $(3,4)$
B. $(5,0)$
C. $(-5,0)$
D. $(4,3)$

Correct Answer: A Difficult Level: 2
4.


The system of equations represented by the graph above is:
$9=(x-2)^{2}+y^{2}$
$y=x^{2}-1$
$y=3 \sqrt{x-1}$
How many solutions does the system have?
$\square$
Correct Answer: 1 Difficult Level: 2
5. The system of equations represented by the graph below is:
$y=-2(x-3)^{2}+5 y=0.5^{x-2}+2$
Which of the following ordered pairs is a solution to the system of equations graphed above?

A. $(2,3)$
B. $(3,2)$
C. $(2,4)$
D. $(4,2)$

Correct Answer: A Difficult Level: 2
6. A rational equation is graphed in the $x y$-plane. The graph has a vertical asymptote with the equation $x=3$ and a horizontal asymptote with the equation $y=0$. Which of the following could be the equation?
A. $y=\frac{1}{x+3}$
B. $\mathrm{y}=\frac{1}{x-3}$
C. $\mathrm{y}=\frac{1}{x}+3$
D. $y=\frac{1}{x}-3$

Correct Answer: B Difficult Level: 2
7. Which of the following graphs represents the equation $y=-2\left(\frac{4}{3}\right)^{x}$ ?


Correct Answer: B Difficult Level: 2
8.


The system of equations represented by the graph above is:
$y=-(x+3)^{2}+5 \quad y=x+6$

If $(-5, b)$ is a solution to the system, then what is the value of $b$ ?
$\square$
Correct Answer: 1 Difficult Level: 2
9. The functions $y=3(x+2)^{2}-4$ and $y=-3(x+2)^{2}-4$ are graphed in the $x y-p l a n e$. Which of the following must be true of the graphs of the vertexes and axes of symmetry of the two functions?
Please choose from one of the following options.
A. The functions will have different vertexes.
B. The functions will have different axes of symmetry.
C. The function $y=3(x+2)^{2}-4$ will have a minimum value, and the function $y=-3(x+2)^{2}-4$ will have a maximum value.
D. The function $y=3(x+2)^{2}-4$ will have a maximum value, and the graph of $y=-3(x+2)^{2}-4$ will have a minimum value.

Correct Answer: B Difficult Level: 2
10.


The system of equations represented by the graph above is:
$y=(x+2)^{2}(x-1) \quad y=x-1$
If $(-1,-b)$ is a solution to the system, then what is the value of $b$ ?


Correct Answer: 2 Difficult Level: 2
11. Which of the following best describes the symmetry in the graph of the function $\mathrm{y}=-\frac{1}{x}$ ?
A. It is symmetric with respect to the x -axis.
B. It is symmetric with respect to the $y$-axis.
C. It is symmetric with respect to the origin.
D. The graph does not show any symmetry.

Correct Answer: C Difficult Level: 2
12.


The functions $f(x)=\sqrt{x+3}-4$ and $g(x)=\sqrt{x+3}+b$ are graphed in the $x y$-plane above.
What is the value of $b$ ?
$\square$
Correct Answer: 5 Difficult Level: 2
13.


The system of equations represented by the graph above is:
$y=-x^{2}+3$

$$
y=-\frac{1}{8}(x-2)^{3}-1
$$

Which of the following ordered pairs is a solution to the system of equations graphed above?
Please choose from one of the following options.
A. $(-1,2)$
B. $(2,-1)$
C. $(-1.8,0)$
D. $(1.8,0)$

Correct Answer: B Difficult Level: 2
14.An exponential equation is graphed in the $x y$-plane BELOW. Which of the following equations represents the graph?

A. $y=2(1.75)^{x}$
B. $y=2(0.75)^{x}$
C. $y=0.75(2)^{x}$
D. $y=1.75(2)^{x}$

Correct Answer: B Difficult Level: 2
15. A parabola has equation $y=2 x^{2}-5 x-3$. What is the $x$-coordinate of the vertex of the parabola?
$\square$
Correct Answer: 1.25 Difficult Level: 2
16. The functions $g(x)=2(x-5)(x-3)$ and $h(x)=2(x+5)(x+3)$ are graphed in the $x y^{-}$ plane. Which of the following is a true statement?
A. The functions have the same y-intercept.
B. The functions have the same x -intercepts.
C. The functions have the same axis of symmetry.
D. The functions have the same vertex.

Correct Answer: A Difficult Level: 3
17. An exponential function is graphed in the xy-plane below. Which of the following equations could represent the graph?

A. $y=2^{x}+1$
B. $y=2^{-x}+1$
C. $y=2\left(\frac{1}{2}\right)^{x}$
D. $y=2\left(\frac{1}{2}\right)^{x}-1$

Correct Answer: B Difficult Level: 3
18. The graph of $f(x)=(x+3)^{2}-5$ is transformed into the graph of $g(x)=a(x+3)^{2}-5$. If the graph of $g$ is shown in the graph at left below, what is the value of $a$ ?

A. -1
B. $-\frac{2}{3}$
C. $\frac{4}{3}$
D. $\frac{4}{9}$

Correct Answer: D Difficult Level: 3
19. The graph of $y=f(x)$ is a parabola that is symmetric with respect to the line $x=-2$. The $y$-coordinate of the vertex of the graph of $f$ is a maximum function value. Which of the following equations could represent function $f$ ?
A. $f(x)=5(x-2)^{2}+3$
B. $f(x)=5(x+2)^{2}+3$
C. $f(x)=-5(x-2)^{2}+3$
D. $f(x)=-5(x+2)^{2}+3$

Correct Answer: D Difficult Level: 3
20. Which of the following shows the graph of the equation $y=2(x+1)^{2}-5$ ?
A.

B.

C.

D.


Correct Answer: A Difficult Level: 3
 vertex of the graph of the equation at $(-3,0)$ ?

Correct Answer: 9 Difficult Level: 3
22. The functions $f(x)=8\left(\frac{2}{5}\right)^{x}$ and $g(x)=8(b)^{x}$ are graphed in the $x y$-plane. For what value of $b$ would the graphs of functions $f$ and $g$ be symmetric with respect to the $y$-axis?

Correct Answer: $5 / 2$ Difficult Level: 3
23. The system of equations represented by the graph below is:
$y=3 x^{2}-8 \quad y=-19(x-1)^{2}+5$
Which of the following ordered pairs is a solution to the system of equations graphed above?

A. $(2,5)$
B. $(5,2)$
C. $(-2,4)$
D. $(-4,2)$

Correct Answer: C Difficult Level: 3
24. The functions $f(x)=5(2)^{x}$ and $g(x)=5(b)^{x}$ are graphed in the $x y$-plane. If the graph of function $g$ is always increasing and $f(x)>g(x)$ for all $x>0$, then which of the following could be the value of $b$ ?
A. 0.25
B. 1.25
C. 2
D. 5

Correct Answer: B Difficult Level: 3
25. Which of the following graphs could represent the equation $y=-(x+2)^{3}$ ?
A.

B.

C.

D.


Correct Answer: B Difficult Level: 3
26. A parabola has equation $y=-3 x^{2}+9 x-2$. What is the $y$-coordinate of the vertex of the parabola?
$\square$
Correct Answer: $\quad 4.75$ Difficult Level: 3
27. A cubic function is graphed in the $x y$-plane BELOW. Which of the following equations could represent the graph?

A. $y=x(x-1)(x+2)$
B. $y=x(x+1)(x-2)$
C. $y=-x(x-1)(x+2)$
D. $y=-x(x+1)(x-2)$

Correct Answer: D Difficult Level: 3
28. Which of the following graphs could represent the equation $y=2^{x+1}$ ?
A.

B.


C.
D.


Correct Answer: A Difficult Level: 3
29. The graph of the equation $y=3(x+6)^{2}+5$ has a $y$-intercept of $(0, b)$. What is the value of $b$ ?
$\square$
Correct Answer: 113 Difficult Level: 3
30. A quadratic function is graphed in the $x y$-plane BELOW. Which of the following equations could represent the graph?

A. $y=3 x^{2}+12 x-5$
B. $y=3 x^{2}+12 x+7$
C. $y=-3 x^{2}-12 x-5$
D. $y=-3 x^{2}-12 x-7$

Correct Answer: C Difficult Level: 3
31. A quadratic function is graphed in the $x y$-plane. The vertex of the parabola is at $(-3,5)$ and the parabola crosses the $y$-axis at $(0,2)$. Which of the following could be the equation for the function?
A. $y=-2(x-3)^{2}+5$
B. $y=-2(x+3)^{2}+5$
C. $y=-\frac{1}{3}(x-3)^{2}+5$
D. $y=-\frac{1}{3}(x+3)^{2}+5$

## Correct Answer: D Difficult Level: 3

32. Which of the following shows the graph of the equation $y=-\sqrt{-x}$ ?
A.

B.

C.

D


Correct Answer: D Difficult Level: 3
33. The function $\mathrm{f}(\mathrm{x})=\sqrt{x-7}$ is graphed in the xy -plane as $\mathrm{y}=\mathrm{f}(\mathrm{x})$. Which of the following statements about the function's graph is true?
A. The graph of the function is always decreasing.
B. The graph of the function intersects the $x$-axis at $(7,0)$.
C. The graph of the function intersects the $y$-axis at $(0,-7)$.
D. The graph of the function is symmetric about the line $x=7$.

Correct Answer: B Difficult Level: 3
34. Functions $f(x)=-2\left(\frac{1}{3}\right)^{x}$ and $g(x)=2\left(\frac{1}{3}\right)^{x}$ are graphed in the $x y$-plane. If $(a, b)$ is a point on the graph of $f$, then which of the following is a point on the graph of $g$ ?
A. $(a, b)$
B. $(-a, b)$
C. $(a,-b)$
D. $(-a, b)$

Correct Answer: C Difficult Level: 3
35. The functions $g(x)=2(x-5)(x-3)$ and $h(x)=2(x+5)(x+3)$ are graphed in the $x y$-plane. Which of the following is a true statement?
A. The functions have the same yy-intercept.
B. The functions have the same xx-intercepts.
C. The functions have the same axis of symmetry.
D. The functions have the same vertex.

Correct Answer: A Difficult Level: 3
36. Functions $f(x)=\sqrt{x+6}$ and $g(x)=\sqrt{x-b}$ are graphed in the $x y$-plane. Let $(c, 0)$ be the $x$-intercept of function $f$ and $(d, 0)$ be the $x$-intercept for function $g$. If $c$ is 15 less than $d$, then what is the value of $b$ ?


Correct Answer: 9 Difficult Level: 4
37. A quadratic function is graphed in the $x y$-plane below. Which of the following equations represents the graph?

A. $y=-\frac{1}{4}(x+5)^{2}+3.25$
B. $y=-\frac{1}{4}(x-5)^{2}+3.25$
C. $y=-\frac{1}{2}(x+5)^{2}+3.25$
D. $y=-\frac{1}{2}(x-5)^{2}+3.25$

Correct Answer: B Difficult Level: 4
38. $y=\frac{1}{4} x+2$

$$
\begin{aligned}
& y=-x^{2}+4 x+3 \\
& x^{2}+y^{2}=25
\end{aligned}
$$

A system of three equations and their graphs in the $x y$-plane are shown at left. How many solutions does the system have?

A. One
B. Two
C. Three
D. Four

Correct Answer: B Difficult Level: 4
39. The functions $f(x)=3(2)^{x}$ and $g(x)=3(2)^{x}-6$ are graphed in the $x y$-plane. If $(0, a)$ is the $y$-intercept of function $f$ and $(0, b)$ is the $y$-intercept of function $g$, then what is the value of $a-b$ ?


Correct Answer: 6 Difficult Level: 4
40. The functions $f(x)=3 x^{2}-3 x+7$ and $g(x)=3 x^{2}-3 x-1$ are graphed in the $x y$-plane. If the graph of function $f$ crosses the $y$-axis at $(0, b)(0, b)$ and the graph of function $g$ crosses the $y$-axis at $(0, c)$, then what is the value of $b-c$ ?


Correct Answer: 8 Difficult Level: 4
41. The function $g(x)=3\left(\frac{1}{2}\right)^{-x}+2$ is graphed in the $x y$-plane. Which of the following is a true statement?
A. The graph of function $g$ is always increasing.
B. The $y$-intercept of the graph of function $g$ is $(0,2)$.
C. The $x$-intercept of the graph of function $g$ is $(0,3)$.
D. Function $g$ is symmetric with respect to the $y$-axis.

Correct Answer: A Difficult Level: 4
42. A rational function is graphed in the $x y$-plane BELOW. Which of the following equations could represent the graph?

A. $y=\frac{x-3}{x-1}$
B. $y=\frac{x+3}{x-1}$
C. $y=\frac{x-1}{x+3}$
D. $y=\frac{x+1}{x+3}$

## Correct Answer: C Difficult Level: 4

43. Which of the following shows the graph of the equation $y=\frac{x+4}{2 x-5}$ ?
A.

B.

C.

D.


Correct Answer: C Difficult Level: 4
44. $y-3=\left(\frac{1}{3}\right)^{x}$

$$
(x-3)^{2}+(y-2)^{2}=16
$$

Which of the following graphs can be used to solve the system of equations shown above?

A.
B.


D.

C.

Correct Answer: B Difficult Level: 4
45. The function with the equation $y=-2 x^{3}+24 x$ is graphed in the $x y x y$-plane. The graph's only 2 relative extremea are a relative minimum at $(-2,-32)$ and a relative maximum at $(2,32)$. Which of the following statements accurately describes where the function is increasing and decreasing?
A. The function is increasing when $x<-2$, decreasing when $-2<x<2$, and increasing when $x>2$.
B. The function is decreasing when $x<-2$, increasing when $-2<x<2$, and decreasing when $x>2$.
C. The function is increasing when $x<-32$, decreasing when $-32<x<32$, and increasing when $x>32$.
D. The function is decreasing when $x<-32$, increasing when $-32<x<32$, and decreasing when $x>32$.

Correct Answer: B Difficult Level: 4
46. A radical function is graphed in the $x y$-plane as below. Which of the following could represent the graph?

A. $\mathrm{y}=\sqrt{3 x+9}$
B. $\mathrm{y}=\sqrt{3 x-9}$
C. $\mathrm{y}=3 \sqrt{x+3}$
D. $\mathrm{y}=3 \sqrt{x-3}$

Correct Answer: A Difficult Level: 4
47. An exponential function is graphed in the $x y$-plane. If the graph of the function is always increasing and its $y$-intercept is $(0,6)$, which of the following could be the equation of the function?
A. $y=6(0.5)^{x}$
B. $y=12(0.5)^{x}$
C. $y=6(2)^{x}+1$
D. $y=4(2)^{x}+2$

Correct Answer: D Difficult Level: 4
48. $y=-2(x-1)^{2}+5$
$3=2 x+y$
Which of the following graphs can be used to solve the system of equations shown above?
A.

B.


D.


Correct Answer: A Difficult Level: 4
49. A function with the equation $y=x^{3}-3 x$ is graphed in the $x y$-plane. The graph's only 2 relative extrema are a relative maximum at $(-1,2)$ and a relative minimum at $(1,-2)$. Which of the following statements accurately describes where the function is increasing and decreasing?
A. The function is increasing when $x<-1$, decreasing when $-1<x<1$, and increasing when $x>1$.
B. The function is decreasing when $x<-1$, increasing when $-1<x<1$, and decreasing when $x>1$.
C. The function is increasing when $x<-2$, decreasing when $-2<\mathrm{x}<2-2<x<2$, and increasing when $x>2$.
D. The function is decreasing when $x<-2$, increasing when $-2<x<2$, and decreasing when $x>2$.

## Correct Answer: A Difficult Level: 4

50. The functions $g(x)=(x+3)^{3}$ and $h(x)=(x-2)^{3}$ are graphed in the $x y$-plane. If $(b, d)$ is a point on the graph of $g$ and $(c, d)$ is a point on the graph of $h$, then what is the value of $b-c$ ?

## Correct Answer: 5 Difficult Level: 4

51. Which of the following graphs represents the equation $y=(x-3)^{3}$ ?


Correct Answer: C Difficult Level: 4

## Linear and quadratic systems

1. Which of the following equations combines with the graphed equation to create a system of equations whose solution set is comprised of the points $(-1,-5)$ and $(3,3)$ ?
Please choose from one of the following options.

A. $y=x^{2}-6$
B. $y=6-x^{2}$
C. $y=4-x^{2}$
D. $y=x^{2}-4$

Correct Answer: A Difficult Level: 2
2. Which of the following represents all solutions $(x, y)$ to the system of equations shown below?
$y=x-2$
$y=x^{2}-x-5$
Please choose from one of the following options.
A. $(3,-1)$
B. $(-3,1)$
C. $(-3,-5)$ and $(1,-1)$
D. $(3,1)$ and $(-1,-3)$

Correct Answer: D Difficult Level: 2
3. Which of the following represents all solutions ( $x, y$ ) to the system of equations shown below?
$y+x=6$
$y=x^{2}-2 x-6$
Please choose from one of the following options.
A. $(-4,10)$ and $(3,3)$
B. $(4,2)$ and $(-3,9)$
C. $(4,-3)$
D. $(-4,3)$

Correct Answer: B Difficult Level: 2
4. Which of the following represents all solutions ( $x, y$ ) to the system of equations created by the equation of this graph and the linear equation $y=x-7$ ?

A. $(4,1)$ and $(9,6)$
B. $(5,-2)$ and $(8,1)$
C. $(5,-2)$ and $(9,6)$
D. $(3,6)$ and $(8,1)$

Correct Answer: B Difficult Level: 2
5. $y=x^{2}+9$
$y=6 x$
If $(x, y)$ is a solution to the system of equations shown above, which of the following is a $y$-coordinate of the solution?
Please choose from one of the following options.
A. 3
B. -3
C. -18
D. 18

Correct Answer: D Difficult Level: 2
6. $-7 x^{2}=(y+5)(y-5)$
$5 y=15 x$
If $(a, b)$ is a solution to the system of equations shown above and $a>0$, what is the value of $a$ ?


$$
\text { 7. } y=2-3 x
$$

$$
y=5 x^{2}
$$

If ( $\mathrm{x}, \mathrm{y}$ ) is a solution to the system of equations shown above and $x>0$, what is the value of $x$ ?

Correct Answer: 2/5

## Difficult Level: 2

8. $y=(x-5)^{2}+1$
$\frac{y-5}{3}=15$
If $(\mathrm{x}, \mathrm{y})$ is a solution to the system of equations shown above and $\mathrm{x}>0$, what is the value of x ?
$\square$
Correct Answer: 12 Difficult Level: 2

$$
\text { 9. } \begin{aligned}
y & =x^{2} \\
y & =1,002 \cdot x-2,000
\end{aligned}
$$

If $\left(\mathrm{x}_{1}, \mathrm{y}_{1}\right)$ and ( $\mathrm{x}_{2}, \mathrm{y}_{2}$ ) are distinct solutions to the system of equations shown above, what is the sum of the $\mathrm{X}_{1}$ and $\mathrm{X}_{2}$ ?

Correct Answer: 1002 Difficult Level: 2

$$
\text { 10. } \begin{aligned}
y & =6 x-30 \\
y & =x^{2}-18 x+114
\end{aligned}
$$

If $(a, b)$ is the solution to the system of equations shown above, what is the value of $b$ ?


## Correct Answer: 42 Difficult Level: 2

11. The concession stand at a football game sells hot dogs and drinks. It costs $\$ 4.25$ for 2 hot dogs and 1 drink. It costs $\$ 7.00$ for 3 hot dogs and 2 drinks. Which of the following systems of equations can be solved to determine the cost h , of each hot dog and the cost d , of each drink?
Please choose from one of the following options.
A. $2 h+d=7.00$
$3 h+2 d=4.25$
B. $2 h+d=4.25$
$3 h+2 d=7.00$
C. $3 h+d=7.00$
$2 h+2 d=4.25$
D. $2 h+2 d=4.25$
$2 h+d=7.00$
Correct Answer: B Difficult Level: 1
12. $a^{2}+1=0$

How many distinct real solutions does the equation above have?
$\square$

## Correct Answer: $0 \quad$ Difficult Level: 1

13. $7 y^{2}=50 x-150$
$y=\frac{3-x}{2}$
If $\left(\mathrm{x}^{1}, \mathrm{y}^{1}\right)$ and $\left(\mathrm{x}^{2}, \mathrm{y}^{2}\right)$ are distinct solutions to the system of equations shown above, what is the product of the $y_{1}$ and $y_{2}$ ?


Correct Answer: $0 \quad$ Difficult Level: 2
14. Which of the following equations combines with the graphed equation to create a system of equations whose solution set is comprised of the points $(-1,-5)$ and $(3,3)$ ?
Please choose from one of the following options.
A. $y=x^{2}-6$
B. $y=6-x^{2}$
C. $y=4-x^{2}$
D. $y=x^{2}-4$

Correct Answer: A Difficult Level: 2
15. Which of the following represents all solutions $(x, y)$ to the system of equations shown below?
$y=x-2$
$y=x^{2}-x-5$
Please choose from one of the following options.
A. $(3,-1)$
B. $(-3,1)$
C. $(-3,-5)$ and $(1,-1)$
D. $(3,1)$ and $(-1,-3)$

Correct Answer: D Difficult Level: 2
16. Which of the following represents all solutions ( $\mathrm{x}, \mathrm{y}$ ) to the system of equations shown below?
$y+x=6$
$y=x^{2}-2 x-6$
Please choose from one of the following options.
A. $(-4,10)$ and $(3,3)$
B. $(4,2)$ and $(-3,9)$
C. $(4,-3)$
D. $(-4,3)$

Correct Answer: B Difficult Level: 2
17. Which of the following represents all solutions $(x, y)$ to the system of equations created by the equation of this graph and the linear equation $y=x-7$ ?


Please choose from one of the following options.
A. $(4,1)$ and $(9,6)$
B. $(5,-2)$ and $(8,1)$
C. $(5,-2)$ and $(9,6)$
D. $(3,6)$ and $(8,1)$

Correct Answer: B

## Difficult Level: 2

18. Which of the following equations could be paired with the graphed equation to create a system of equations whose solution set is comprised of the points $(2,-4)$ and $(-4,2)$ ?


Please choose from one of the following options.
A. $x-y=-6$
B. $y-x=6$
C. $x-y=-2$
D. $y+x=-2$

Correct Answer: D Difficult Level: 3
19. Which of the following represents all solutions $(x, y)$ to the system of equations shown below?
$y+2 x^{2}=3 x+16$
Please choose from one of the following options.
A. $(4,-4)$ and $(-2,2)$
B. $(-4,4)$ and $(2,-2)$
C. $(2,-4)$
D. $(4,-2)$

Correct Answer: A Difficult Level: 3
20. Which of the following represents all solutions $(x, y)$ to the system of equations created by the linear equation and the quadratic equation $\mathrm{y}^{2}=\mathrm{x}+4$ ?


Please choose from one of the following options.
A. $(2,0)$ and $(-3,5)$
B. $(5,-3)$ and $(0,2)$
C. $(2,0)$ and $(0,2)$
D. $(0,2)$ and $(3,-1)$

Correct Answer: B Difficult Level: 3
21. $y^{2}+25=x$
$10 y=x$
If $(\mathrm{x}, \mathrm{y})$ is a solution to the system of equations shown above, which of the following is an $x$-coordinate of the solution?
Please choose from one of the following options.
A. 50
B. -50
C. -5
D. 5

Correct Answer: A Difficult Level: 3
22. Which of the following equations could be paired with the graphed equation to create a system of equations whose solution set is comprised of the points $(2,-2)$ and $(-3,3)$ ?


Please choose from one of the following options.
A. $y=x+6$
B. $y=x-6$
C. $y=x$
D. $y=-x$

Correct Answer: D Difficult Level: 3

$$
\text { 23. }-3 y-4=9 x+2, ~ \begin{gathered}
y-4 x-2 x^{2}=3
\end{gathered}
$$

If $(\mathrm{x}, \mathrm{y})$ is a solution to the system of equations shown above, which of the following are $x$-coordinates of the solutions?
Please choose from one of the following options.
A. $\frac{5}{2}$ and 1
B. $-\frac{5}{2}$ and -1
C. -1 and 1
D. $-\frac{5}{2}$ and $\frac{11}{2}$

Correct Answer: B
Difficult Level: 4
24. $x^{2}+y^{2}=10$

$$
x-2 y=5
$$

If $(x, y)$ is a solution to the system of equations shown above, which of the following are $y$-coordinates of the solutions?

Please choose from one of the following options.
A. 0 and $\sqrt{10}$
B. 0and $-\sqrt{10}$
C. -3 and -1
D. 3 and 1

Correct Answer: C Difficult Level: 4
25. If ( $x, y$ ) is a solution to the system of equations shown below, what is the product of the $y$-coordinates of the solutions?

$$
\begin{aligned}
& x^{2}+4 y^{2}=40 \\
& x+2 y=8
\end{aligned}
$$

$\square$

## Correct Answer: 3 Difficult Level: 4

26. If $(\mathrm{x}, \mathrm{y})$ is a solution to the system of equations shown below, what is the product of the y -coordinates of the solutions?
$x^{2}+y^{2}=9$
$x+y=3$


Correct Answer: $0 \quad$ Difficult Level: 4
27.The graph at left shows the parabola $y=-(x+4)^{2}+5$. Consider the following linear equation:
$y=-3 x+b$
for some constant $b$. If one of the solutions to the system of equations formed by the parabola and the linear equation is $(-4,5)$, which of the following is the other solution?
Please choose from one of the following options.
A. $(-7,-4)$
B. $(-6,1)$
C. $(-1,-4)$
D. $(-2,1)$

Correct Answer: C Difficult Level:4
28. Which of the following represents all solutions (x,y) to the system of equations created by the equation of this graph and the linear equation $x-y=3$ ?

A. $(-3,0)$ and $(-5,-3)$
B. $(3,0)$ and $(5,-3)$
C. $(-3,0)$ and $(4,-7)$
D. $(3,0)$ and $(-4,-7)$

Correct Answer: D

## Difficult Level: 3

29. $x-3=8=$
$y^{2}=x-4 y-2$
If $(x, y)$ is a solution to the system of equations shown above, which of the following are
$y$-coordinates of the solutions?
Please choose from one of the following options.
A. -1 and -3
B. 14 and 2
C. -2 and 3
D. 2 and -3

Correct Answer: D
Difficult Level: 3
30. The graph at left shows the line $y=3 x+33$. Which of the following is one of the two solutions $(x, y)$ to the system of equations formed by this line and the curve
$y=-3(x+10)^{2}+9$ ?
Please choose from one of the following options.
A. $(-11,0)$
B. $(-8,9)$
C. $(-12,-3)$
D. $(-13,-6)$

Correct Answer: C Difficult Level: 3
31. The graph at left shows the line $y=-\frac{1}{2} x+4$. Which of the following gives all the solutions $(x, y)$ to the system of equations formed by this line and the curve $y=\frac{1}{4} x^{2}+2$ ?


Please choose from one of the following options.
A. $(2,3)$ and $(-4,6)$
B. $(-2,5)$ and $(-4,6)$
C. $(2,3)$ and $(-2,3)$
D. $(-2,5)$ and $(4,2)$

Correct Answer: A
Difficult Level: 3
32. The graph at left shows the equation $y^{2}+2 y=15+x$. Which of the following are the two solutions ( $\mathrm{x}, \mathrm{y}$ ) to the system of equations formed by this equation and the line $y=\frac{1}{2} x+3$ ?


Please choose from one of the following options.
A. $(-12,1)$ and $(0,3)$
B. $(-12,-3)$ and $(0,-5)$
C. $(-12,-3)$ and $(0,3)$
D. $(-12,1)$ and $(0,-5)$

Correct Answer: C Difficult Level: 3
33. The graph at left shows the parabola $y=\frac{1}{3} x^{2}-2 x-4$. Which of the following is the solution $(x, y)$ to the system of equations formed by this parabola and the line $y=-\frac{8}{3}(x+5)+9$ ?


Please choose from one of the following options.
A. $(0,-4)$
B. $\left(4,-\frac{20}{3}\right)$
C. $(3,-7)$
D. $\left(-1,-\frac{5}{3}\right)$

## Correct Answer: D

 Difficult Level: 434. The graph at left shows the equation $y^{2}+2 y=15+x$. Which of the following are the two solutions ( $\mathrm{x}, \mathrm{y}$ ) to the system of equations formed by this equation and the line $y=\frac{1}{2} x+3$ ?


Please choose from one of the following options.
A. $(-12,1)$ and $(0,3)$
B. $(-12,-3)$ and $(0,-5)$
C. $(-12,-3)$ and $(0,3)$
D. $(-12,1)$ and $(0,-5)$

Correct Answer: C
Difficult Level: 4
35.


The graph above shows the parabola $y=-36 x^{2}-50$. Which of the following is the solution $(\mathrm{x}, \mathrm{y})$ to the system of equations formed by this parabola and the line $y=120 x+50$ ?
A. $\left(\frac{2}{3},-70\right)$
B. $\left(-\frac{4}{3},-110\right)$
C. $\left(-\frac{5}{3},-150\right)$
D. $\left(\frac{4}{3},-114\right)$

Correct Answer: C
Difficult Level: 4
36. $2 x-3 y=15$
$y=-\frac{1}{3}\left(x^{2}-16 x+63\right)$
$\operatorname{If}(x, y)$ is a solution to the system of equations shown above and $y>0$, what is the value of $x$ ?
$\square$
Correct Answer:8 Difficult Level: 4
37. $-2-x=\frac{y 2-4 y+10}{11}$
$-11 x+3 y=62$
If $\left(x_{1}, y_{1}\right)$ and $\left(x_{2}, y_{2}\right)$ are two distinct solutions to the system of equations shown above, what is the product of the $x$ values of the two solutions $x_{1} \cdot x_{2}$ ?


Correct Answer:28
Difficult Level: 4
38. $y=x+4$

$$
\frac{y+3}{4}=7 x^{2}-x+1
$$

If $(a, b)$ is a solution to the system of equations shown above and $a>0$, what is the value of $a$ ?
Correct Answer:3/7
Difficult Level: 4
39. $y=-3 x$

$$
\frac{y-7}{6}=\frac{3 x 2+x-5}{2}
$$

If $\left(x_{1}, y_{1}\right)$ and $\left(x_{2}, y_{2}\right)$ are the distinct solutions to the system of equations shown above, what is the sum of the $y 1+y 2$ ?
$\square$
Correct Answer: 2
Difficult Level: 4
40. $y=\frac{1}{5} x-9$

$$
5 y_{2}+15=7 x
$$

If $(a, b)$ is a solution to the system of equations shown above and $b>0$, what is the value of $b$ ?


## Structure in expressions

1. $4^{2}(20 k)^{-7}$

Which of the following is equivalent to the above expression?
A. $4^{2}(20+k)-7$
B. $4^{2}\left(\frac{20}{k}\right)-7$
C. $20 k \cdot 4^{2}-7$
D. $\left(\frac{4^{2} \cdot 20}{k}\right)-7$

Correct Answer: C Difficult Level: 2
2. $\left(5 j^{2} k\right)^{3}+(\theta-3)$

Which of the following is equivalent to the above expression?
A. $(\theta-3)+\left(125 k^{3} j^{6}\right)$
B. $(\theta-3)+\left(5 j^{2} k^{3}\right)$
C. $\left(125 k^{3}{ }^{6}\right)+(3-\theta)$
D. $\left(5 j^{2} k^{3}\right)+(3-\theta)$

Correct Answer: A Difficult Level: 2
3. $\left(4 s^{2} t\right)^{3}+(p-3)$

Which of the following is equivalent to the above expression?
A. $\left(4^{3} s^{23} t^{3}\right)+(p-3)$
B. $(p-3)+\left(4 s^{2} t^{3}\right)$
C. $\left(12 s^{2} t\right)+(p-3)$
D. $(p-3)+\left(64 s^{6} t^{3}\right)$

Correct Answer: D Difficult Level: 2
4. $\frac{x^{2}-16}{(\mathrm{x}-3)(\mathrm{x}+6)} \div \frac{(x+a)(a-x)}{x^{2}+c x-18}=-1$

Given the equation above, what is the value of $c$ ?


Correct Answer: 3 Difficult Level: 2
5. $A^{3}+B^{3}=(C+8 y)(D-40 x y+E)$

A partial factorization of a sum of cubes is given above. Which of the following is equivalent to $A+B$ ?
A. $13 x y$
B. $20 x+2 y$
C. $2.5 x+8 y$
D. $5 x+8 y$

Correct Answer: D Difficult Level: 2
6. $\frac{\left(\frac{x-y}{6}\right)}{\left(\frac{x-y}{12}\right)}$

Which of the following is equivalent to the above expression for $x \neq y$ ?
A. 2
B. $\frac{1}{2}$
C. $\frac{x-y}{2}$
D. $\frac{(x-y)^{2}}{72}$

Correct Answer: A Difficult Level: 2
7. $\left(n^{6} k^{14}\right)^{5}$

Which of the following is equivalent to the above expression?
A. $\left(n^{2} k^{5}\right)^{3}$
B. $\left(n^{3}\right)^{10}\left(k^{2}\right)^{7}$
C. $\left(n^{15} k^{35}\right)^{2}$
D. $\left(n^{5}\right)^{5}\left(k^{10}\right)^{7}$

Correct Answer: C Difficult Level: 2
8. $\frac{\frac{a}{b}}{c}+\frac{d}{\frac{e}{f}}$

Which of the following is equivalent to the above expression?
A. $\frac{a}{b c}+\frac{d f}{e}$
B. $\frac{a}{b c}+\frac{d e}{f}$
C. $\frac{b c}{a}+\frac{d f}{e}$
D. $\frac{b c}{a}+\frac{d e}{f}$

Correct Answer: A Difficult Level: 2
9. The expression
$\left(x^{2}+h^{2}\right)\left(x^{2}-h^{2}\right)$
can be written as
$(1+m-p) x^{4}-m p$
where $h, m, p$, and $b$ are constants. What is one possible value of $m$ ?
A. 1
B. $h$
C. $h^{2}$
D. $h^{4}$

Correct Answer: C Difficult Level: 2
10. $(a+b+c)(a-b-c)$

Which of the following is equivalent to the above expression?
A. $\mathrm{a}(\mathrm{b}+\mathrm{c})-(\mathrm{a}+\mathrm{b}) \mathrm{c}$
B. $a^{2}(b+c)-(a+b) c^{2}$
C. $a^{2}-(b+c)^{2}$
D. $(a+b)^{2}-c^{2}$

Correct Answer: C Difficult Level: 3
11. $\frac{\left(\frac{3}{a+b}\right)}{3(a+b)}$

Which of the following is equivalent to the above expression for $a \neq-b$ ?
A. 1
B. 9
C. $\frac{1}{a^{2}+b^{2}}$
D. $\frac{1}{a^{2}+2 a b+b^{2}}$

Correct Answer: D Difficult Level: 3
12. $\frac{\frac{a b}{x y}}{\frac{i j}{m n}}$

Which of the following is equivalent to the above expression?
A. $\frac{(a x)(i m)}{(b y)(j n)}$
B. $\frac{a(b m) n}{x(y i) j}$
C. $\frac{(a b)(i j)}{(x y)(m n)}$
D. $\frac{a(b x) y}{i(j m) n}$

Correct Answer: B Difficult Level: 3
13. $(a+b+c)^{2}$

Which of the following is equivalent to the above expression?
A. $a^{2}+b^{2}+c^{2}+2(a b+b c+c a)$
B. $a^{2}+b^{2}+c^{2}$
C. $a^{2}+2 a b c+c^{2}$
D. $a^{2}+2 a b+b^{2}+2 b c+c^{2}$

Correct Answer: A Difficult Level: 3
14. $\frac{x y}{a}+\frac{x^{2} y^{2}}{b}$

Which of the following is equivalent to the above expression?
A. $\frac{x y(b-a x y)}{a b}$
B. $x y\left(\frac{x y}{b}-\frac{1}{a}\right)$
C. $\left(\frac{x y}{a}-\frac{1}{b}\right) \mathrm{yx}$
D. $\frac{x y(a-b x y)}{a b}$

Correct Answer: A Difficult Level: 3
15. $\frac{m+n}{4}-\frac{4}{m+n}=\frac{(x-4)(x+4)}{4(m+n)}$

Which of the following is equivalent to $x$ if the above equation is true for all $m \neq n$ ?
A. $\sqrt{m-n}$
B. $\sqrt{m+n}$
C. $m-n$
D. $m+n$

## Correct Answer: D Difficult Level: 4

16. $(y t)^{6 t-}(l v)^{8 v}$

Which of the following is equivalent to the above expression?
A. $y^{6} t^{t}-l^{8} v^{v}$
B. $v^{8 v} l^{8 v}-t^{6 t} y^{6 t}$
C. $\left((l v)^{4 v}+(y t)^{3 t}\right)\left((l v)^{4 v}-(y t)^{3 t}\right)$
D. $\left((v l)^{v 4}+(t y)^{13}\right)\left((t y)^{t 3}-(v l)^{v 4}\right)$

Correct Answer: D Difficult Level: 4
17. $\left(y^{2}-32 y+256-k\right)\left(y^{2}-32 y+256+k\right)=(y-16)^{4}-100$

What is the value of $k^{2}$ in the above equation?


Correct Answer: $\quad 100$ Difficult Level: 4
18. $\left(a^{m}\right)^{n} a^{m n}$

Which of the following is equivalent to the above expression?
A. $2 a^{n n}$
B. $a^{2 m n}$
C. $a^{m^{2} n^{2}}$
D. $a^{m^{n}+m n}$

Correct Answer: B Difficult Level: 4
19. $s^{3} t^{3}+1$

Which of the following is equivalent to the above expression?
A. $(s t-1)\left(s^{2} t^{2}+s t+1\right)$
B. $(s t-1)\left((s t)^{2}-s t+1\right)$
C. $(s t+1)\left(s^{2} t^{2}+s t+1\right)$
D. $(s t+1)\left((s t)^{2}-s t+1\right)$

Correct Answer: D Difficult Level: 4
20. If $2^{m}=x$ and $7^{n}=y$, then which of the following is equivalent to $784^{m n}$ ?
A. $x^{2 m} y^{4 n}$
B. $x^{2 n} y^{4 m}$
C. $x^{4 m} y^{2 n}$
D. $x^{4 n} y^{2 m}$

Correct Answer: D Difficult Level: 4
21. $\frac{p+7}{7}-\frac{p-7}{7}$

Which of the following is equivalent to the above expression?
A. $\frac{p-p}{7}$
B. $\frac{p+p}{7}$
C. $\frac{7+7}{7}$
D. $\frac{7-7}{7}$

## Correct Answer: C Difficult Level: 4

22. $\frac{x^{2}-2 x-8}{x+3} \cdot \frac{x+2}{x+3}$

Which of the following is equivalent to the above expression for $x \neq-3$ ?
A. $\frac{2(x-4)(x+2)}{3(x+3)}$
B. $\frac{(x-4)(x+2)^{2}}{x+3}$
C. $\frac{(x-4)(x+2)^{2}}{x^{2}+6 x+9}$
D. $\frac{2(x-4)(x+2)}{x^{2}+6 x+9}$

## Correct Answer: C Difficult Level: 4

23. $\left(w-\frac{3}{2}\right)\left(w+\frac{7}{2}\right)$

Which of the following is equivalent to the above expression?
A. $\frac{(w-3)(w+7)}{2}$
B. $\frac{(2 w+7)(2 w-3)}{2}$
C. $\frac{(w-3)(w+7)}{4}$
D. $\frac{(2 w+7)(2 w-3)}{4}$

Correct Answer: D Difficult Level: 4
24. $c(a x-b)-d(b-a x)$

Which of the following is equivalent to the above expression?
A. $(a x-b)(c+d)$
B. $(a x-b)^{2}(c+d)$
C. $(b-a x)^{2}(c-d)$
D. $(a x-b)(b-a x)(c-d)$

Correct Answer: A Difficult Level: 4
25. $(u+t)^{3}$

Which of the following is equivalent to the above expression?
A. $u^{3}+3 u t+t^{3}$
B. $u^{3}+3 u t(u+t)+t^{3}$
C. $u^{3}+6 u t+t^{3}$
D. $u^{3}+6 u^{2} t+6 u t^{2}+t^{3}$

Correct Answer: B Difficult Level: 4
26. $\frac{a+b}{c-d}-\frac{a+b}{d-c}$

Which of the following is equivalent to the above expression for $c \neq d$ ?
A. 0
B. $\frac{2 b}{c-d}$
C. $\frac{2(a+b)}{c-d}$
D. $\frac{2 a+2 b}{2 c-2 d}$

Correct Answer: C Difficult Level: 4
27. If $x^{3}+b^{3}=(x+b)\left(x^{2}-x b+9\right)$, what is a possible value of $b$ ?
$\square$
Correct Answer: 3 或-3 Difficult Level: 2
28. $a^{2} x-3 a^{2}+2 x-6$

Which of the following is equivalent to the above expression?
A. $\left(a^{2}\right)(x-3)-2(x+3)$
B. $(a x+3)(a-2)$
C. $(x+3)\left(a^{2}-2\right)$
D. $(x-3)\left(a^{2}+2\right)$

Correct Answer: D Difficult Level: 4

## Isolating Quantities

1. $C=1.2272 M+3.0556 F$

An English teacher uses the equation above to give the composite score, $C$, on the final exam, given $M$ correct multiple choice answers and $F$ points on the free response questions. Which of the following equations correctly gives the number of correct multiple choice answers in terms of the composite score and the number of points on the free response questions?
A. $\mathrm{M}=\frac{\mathrm{C}-3.0556 F}{1.2272}$
B. $\mathrm{M}=\frac{\mathrm{C}}{1.2272}-3.0556 F$
C. $\mathrm{M}=\frac{3.0556 F-C}{1.2272}$
D. $\mathrm{M}=\frac{3.0556 F}{1.2272}-C$

Correct Answer: A Difficult Level: 2
2. $\mathrm{c}=\frac{4 b}{\sqrt[3]{d}}$

The formula above gives the capsize screening value, $c$, for a sailboat with a beam $b$ feet long and that displaces $d$ pounds of water. Higher capsize screening values suggest that a sailboat is more stable. Which of the following equations correctly gives the displacement in terms of the capsize screening value and the beam length?
A. $\mathrm{d}=\frac{(4 b)^{3}}{c}$
B. $\mathrm{d}=\frac{c^{3}}{4 b}$
C. $\mathrm{d}=\left(\frac{4 b}{c}\right)^{3}$
D. $\mathrm{d}=\left(\frac{c}{4 b}\right)^{3}$

Correct Answer: C Difficult Level: 2
3. $\mathrm{A}=\frac{\pi r^{2} \theta}{360}$

The above equation can be used to find the area, $A$, of a sector of a circle of radius, $r$, where $\theta$ is the sector's central angle in degrees. Which of the following correctly shows the circle sector's radius in terms of the area of the sector and the central angle?
A.r $=\sqrt{\frac{360 A}{\pi \theta}}$
B. $\mathrm{r}=\frac{360 \mathrm{~A}}{\pi r \theta}$
C. $\mathrm{r}=\sqrt{\frac{\pi \theta}{360 A}}$
D. $\mathrm{r}=\frac{\pi \theta}{360 \mathrm{Ar}}$

Correct Answer: A Difficult Level: 2
4. $x_{\text {mid }}=\frac{x 1+x 2}{2}$

The formula above gives the $\mathrm{x} x$-coordinate, $x$ mid, of the midpoint of a line segment whose endpoints have $x$-coordinates $x_{1}$ and $x_{2}$. Which of the following equations correctly gives the $x$-coordinate of the second endpoint, $x 2$, in terms of the $x \backslash x$-coordinates of the first endpoint and of the midpoint?
A. $x_{2}=2 x_{\text {mid }}-x_{1}$
B. $x_{2}=2 x_{\text {mid }}-\frac{x 1}{2}$
C. $x_{2}=2 x_{\text {mid }}-2 x_{1}$
D. $x_{2}=x_{\text {mid }}-\frac{x 1}{2}$

Correct Answer: A Difficult Level: 2
5. $F=G \frac{M m}{r^{2}}$

The gravitational force, $F$, of attraction can be determined for two objects of mass, $M$ and $m$, separated by a distance, $r$, through the equation shown above, where $G$ is the gravitational constant. Which of the following is the correct expression for mass, $m$, in terms of the force, gravitational constant, mass $M$, and the separation distance?
A. $\mathrm{m}=\mathrm{G} \frac{M F}{r^{2}}$
B. $\mathrm{m}=\frac{F G r^{2}}{M}$
C. $\mathrm{m}=\frac{F r^{2}}{G M}$
D. $\mathrm{m}=\frac{F}{G M r^{2}}$

Correct Answer: C Difficult Level: 2
6. $v=331.3 \sqrt{1+\frac{T}{273.15}}$

The formula above gives the velocity, $v v$, in meters per second, at which sound travels through air that is at a temperature of TT degrees Celsius. Which of the following equations correctly gives the air temperature in terms of the velocity of sound?
A. $T=273.15\left(\frac{v^{2}}{331.3^{2}}-1\right)$
B. $T=273.15\left(\frac{v^{2}}{331.3^{2}}\right)-1$
C. $T=273.15(v-331.3)^{2}$
D. $T=273.15\left(\frac{v-331.3}{331.3}\right)^{2}$

Correct Answer: A Difficult Level: 3
7.


$$
\frac{\sin A}{a}=\frac{\sin B}{b}
$$

The Law of Sines, shown above, where $A$ and $B$ represent any two angles of a triangle and $a$ and $b$ represent the lengths of the sides opposite those angles, states that the sines of the angles of a triangle and the lengths of the sides opposite those angles are proportional. Which of the following shows $a$ in terms of $\sin A, \sin B$, and $b$ ?
A. $a=b$
B. $\mathrm{a}=\frac{\sin A}{\mathrm{~b} \sin B}$
C. $\mathrm{a}=\frac{\mathrm{b} \sin A}{\sin B}$
D. $\mathrm{a}=\frac{\mathrm{b} \sin B}{\sin A}$

Correct Answer: C Difficult Level: 3
8. $v_{r m s}=\sqrt{\frac{3 R T}{\mathrm{Mm}}}$

The root-mean-square speed is the measure of the speed of particles in a gas. Root-mean-square speed, $v_{r m s}$, can be calculated using the equation shown above, where $M_{m}$ is the molar mass of a gas, $R$ is the molar gas constant, and $T$ is the temperature. Which of the following equations correctly expresses the molar mass of a gas in terms of root-mean-square speed, temperature, and the molar gas constant?
A. $\mathrm{M}_{\mathrm{m}}=\left(\frac{3 R T}{V r m s}\right)^{2}$
B. $\mathrm{M}_{\mathrm{m}}=\frac{3 R T}{(V r m s)^{2}}$
C. $\mathrm{M}_{\mathrm{m}}=\frac{V r m s^{2}}{3 R T}$
D. $\mathrm{M}_{\mathrm{m}}=\frac{\sqrt{3 R T}}{V r m s}$

Correct Answer: B Difficult Level: 3
9. $p^{2}+2 p q+q^{2}=1$

In genetics, the Hardy-Weinberg Law states that if 2 different versions, or alleles, of a gene are present in proportions $p$ and $q$, then how they are expressed in successive generations is governed by the equation above, where the proportions, $p$ and $q$, are numbers between 0 and 1 , inclusive.
Which of the following correctly expresses allele $p$ in terms of allele $q$ ?
A. $(p+q)^{2}=1$
B. $(p+q)^{2}=0$
C. $p=-q \pm 1$
D. $p=-q$

## Correct Answer: C Difficult Level: 3

10. $\mathrm{a}=\frac{5 b c}{20}+10$

Which of the following equations gives $b$ in terms of $a$ and $c$ ?
A. $b=\frac{4 a}{c}-200$
B. $b=\frac{4 a-40}{c}$
C. $b=\frac{4 a}{c}-10$
D. $b=\frac{4 a+40}{c}$

## Correct Answer: B Difficult Level: 3

11. $j=\frac{m}{c} 78$

Which of the following equations correctly gives $c$ in terms of $j$ and $m$ ?
A. $c=\frac{m}{j} 78$
B. $c=\frac{m}{78 j}$
C. $c=\frac{j}{m} 78$
D. $c=\frac{j}{78 m}$

Correct Answer: A Difficult Level: 3

$$
\text { 12. } T=\sqrt{(\mu g x)^{2}+(T 0)^{2}}
$$

The equation above gives the tension, $T$, at a point of the cable of a suspension bridge whose horizontal distance from its lowest point of the cable is $x$ meters, where the cable has a mass to length ratio of $\mu$, and a tension of $T_{0}$ at the lowest point. The constant $g$ represents the gravitational acceleration in meters per second. Which of the following equations correctly gives $x$ in terms of $T, T 0$, and $\mu$ ?
A. $x=\frac{T-T_{0}}{\mu g}$
B. $x=\frac{T-\left(T_{0}\right)^{2}}{\mu g}$
C. $x=\frac{\sqrt{T^{2}-(T 0)^{2}}}{\mu g}$
D. $x=\frac{T^{2}-\left(T_{0}\right)^{2}}{\mu g}$

## Correct Answer: C Difficult Level: 3

13. $U=\frac{1}{2} k x^{2}$

The elastic energy of an object, $U$, is determined by the amount of its compression, $x$, and the spring constant of the object, $k$, as shown in the formula above. Which of the following correctly shows the object's absolute compression in terms of its elastic energy and spring constant?
A. $x=\sqrt{\frac{k U}{2}}$
B. $x=\sqrt{\frac{2 U}{k}}$
C. $x=\frac{\sqrt{2 U}}{k}$
D. $x=\left(\frac{2 U}{k}\right)^{2}$

## Correct Answer: B Difficult Level: 3

## 14. $V=\pi r^{2} h$

The volume, $V$, of a cylinder of radius, $r$, and height, $h$, can be found with the equation above.
Which of the following correctly expresses the cylinder's radius in terms of its volume and height?
A. $r=\frac{\sqrt{V h}}{\pi}$
B. $r=\sqrt{\frac{V h}{\pi}}$
C. $r=\frac{\sqrt{V}}{\pi h}$
D. $r=\sqrt{\frac{V}{\pi h}}$

Correct Answer: D Difficult Level: 3
$15 . \mathrm{Q}=\frac{A-I}{L}$
The formula above gives the quick assets ratio $Q$ in terms of a company's current assets, $A$; inventories, $I$; and current liabilities, $L$. Which of the following equations correctly gives the inventories in terms of the quick assets ratio, the current assets, and the current liabilities?
A. $I=Q L-A$
B. $I=A-Q L$
C. $I=L(Q-A)$
D. $I=L(A-Q)$

Correct Answer: B Difficult Level: 4
16. $h=H\left(1-\frac{a}{b}\right)$

Continental crust sits much higher than oceanic crust because of differences in density. In fact, for many objects with a similar shape and of known height, $H$, and density, $a$, floating in a fluid of density, $b$, the distance, $h$, that it protrudes above the liquid's surface can be determined by the equation shown above. Which of the following correctly expresses the object's density in terms of the protrusion distance, object height, and fluid density?
A. $a=b\left(\frac{h}{H}-1\right)$
B. $a=b\left(1-\frac{h}{H}\right)$
C. $a=\left(\frac{b h}{H}-1\right)$
D. $a=\left(1-\frac{b h}{H}\right)$

## Correct Answer: B Difficult Level: 4

17. $R=\frac{C-P}{P}$

To determine the value of a country's economy, a number called the Gross Domestic Product, or GDP is used. The current annual growth rate, $R$, can be determined from the current year's GDP, $C$, and the previous year's GDP, $P$, by using the following relationship. Which of the following correctly shows the previous year's GDP in terms of the growth rate and the current year's GDP?
A. $R=C-1$
B. $P=C-R-1$
C. $P=\frac{C}{R}+1$
D. $P=\frac{C}{R+1}$

## Correct Answer: D Difficult Level: 4

18. $x=v t+\frac{1}{2} a t^{2}$

The horizontal displacement, $x$, of an object with constant acceleration, $a$, initial velocity, $\quad v$, at elapsed time, $t$, is given by the above equation. Which of the following equations correctly shows the acceleration in terms of displacement, initial velocity, and time?
A. $a=\frac{2 \sqrt{x-t v_{0}}}{t}$
B. $a=\frac{2\left(x-v_{0}\right)}{t}$
C. $a=\frac{2\left(x-t v_{0}\right)}{t^{2}}$
D. $a=\frac{2 x}{t^{3} v_{0}}$

## Correct Answer: C Difficult Level: 4

19. $r=\sqrt{x^{2}+y^{2}}$

The radius, $r$, of a circle whose center is at the origin and that passes through the point $(x, y)$ can be found with the equation above. Which of the following correctly shows a possible value of the $x$-coordinate in terms of its radius and $y$-coordinate?
A. $x=\sqrt{r^{2}}-y^{2}$
B. $x=\sqrt{r^{2}-y^{2}}$
C. $x=\sqrt{r^{2}+y^{2}}$
D. $x=r-y$

## Correct Answer: B Difficult Level: 4

20. $r=447.593+9.247 w+3.098 h-4.33 a$

The Harris-Benedict equation above gives the basal metabolic rate, $r$, for a woman who weighs $w$ kilograms, is $h$ centimeters tall, and is $a$ years old. Which of the following equations correctly gives the weight of the woman in terms of her basal metabolic rate, height, and age?
A. $w=\frac{r}{9.247}-447.593-3.098 h-4.33 a$
B. $w=\frac{r}{9.247}-447.593-3.098 h+4.33 a$
C. $w=\frac{r-447.593-3.098 h-4.33 a}{9.247}$
D. $w=\frac{r-447.593-3.098 h+4.33 a}{9.247}$

## Correct Answer: D Difficult Level: 4

21. $\mathrm{C}=\frac{a b}{a+b}$

For two capacitors, wired in series, the equivalent capacitance, $C$, can be expressed in terms of the capacitance, $a$ and $b$, of each capacitor, with the above equation. Which of the following correctly expresses the capacitance of capacitor $a$ in terms of capacitor $b$ 's capacitance and the equivalent capacitance?
A. $a=\frac{c}{1-C}$
B. $a=C b(b-C)$
C. $a=\frac{C b}{b-C}$
D. $a=\frac{c b}{b+c}$

## Correct Answer: C Difficult Level: 4

22. $L=\pi r \sqrt{h^{2}+r^{2}}$

The lateral surface area, $L$, of a right circular cone with radius, $r$, and height, $h$, can be found with the equation above. Which of the following correctly shows the right circular cone's height in terms of its radius, lateral surface area, and $\pi$ ?
A. $h=\sqrt{\frac{L^{2}}{\pi r}+r^{2}}$
B. $h=\sqrt{\frac{L}{\pi r}+r^{2}}$
C. $h=\sqrt{\left(\frac{L}{\pi r}\right)^{2}+r^{2}}$
D. $h=\frac{L}{\pi r}-\mathrm{r}$

## Correct Answer: C Difficult Level: 4

23. $C_{\mathrm{i}} V_{\mathrm{i}}=C \mathrm{f}\left(V_{i}+V_{d}\right)$

The formula above relates the initial concentration, $C \mathrm{i}$, and final concentration, $C \mathrm{f}$, of a solute, the initial volume, $V_{\mathrm{i}}$, of a solution, and the volume, $V d$, of diluting substance added. Which of the following equations correctly gives the volume of diluting substance added in terms of the initial volume and the initial and final concentrations?
A. $V_{d}=C_{i} V_{i}-C f V_{\mathrm{i}}$
B. $V_{d}=\frac{C_{i} V_{i}-V_{i}}{C_{\mathrm{f}}}$
C. $V_{d}=\frac{C_{\mathrm{f}} V_{\mathrm{i}}}{C_{\mathrm{i}}-C_{\mathrm{f}}}$
D. $V_{d}=V_{i}\left(\frac{C_{\mathrm{i}}}{C_{\mathrm{f}}}-1\right)$

Correct Answer: D Difficult Level: 4
24. $\frac{1}{f}=\frac{1}{o}+\frac{1}{i}$

By bending incoming light rays through a focal point, a thin lens of focal length $f$ will turn an object that is $o$ units from the lens into an image that is $i i$ units from the lens, according to the thin lens equation, shown above. Which of the following correctly shows the object distance in terms of the focal length and the image distance?
A. $o=f-i$
B. $o=f i(i-f)$
C. $o=\frac{f i}{i-f}$
D. $o=\frac{1}{i-f}$

## Correct Answer: C Difficult Level: 4

25. $\cdot \frac{V_{1}}{T_{1}}=\frac{V_{2}}{T_{2}}$

Charles's law, for ideal gases relates the volume, $V$, and temperature, $T$, of an ideal gas in its initial(1) and final (2) states. Which of the following shows the initial temperature in terms of the final temperature, the initial volume, and final volume?
A. $T_{1}=T_{2}$
B. $T_{1}=V_{1}-\frac{V_{2}}{T_{2}}$
C. $T_{1}=\frac{V_{2}}{T_{2} V_{1}}$
D. $T_{1}=\frac{T_{2} V_{1}}{V_{2}}$

Correct Answer: D Difficult Level: 4
26. $t=\frac{72}{b-d+m}$

The equation above gives the approximate doubling time in years, $t$, of the population of a country with a $b$ percent annual increase due to births, a $d$ percent annual decrease due to deaths, and a net migration of $\mathrm{m} m$ percent relative to the initial population over the course of a year. Which of the following equations correctly gives the net migration percent in terms of the doubling time, percent increase from births, and percent increase from deaths over the course of a year?
A. $m=\frac{72}{b-d+t}$
B. $m=\frac{72}{t b-\mathrm{t} d}$
C. $m=\frac{72}{t}-\mathrm{b}+\mathrm{d}$
D. $m=\frac{72-b+d}{t}$

## Correct Answer: C Difficult Level: 4

27. The area, $A$, of the unshaded circular ring shown BELOW can be found with the equation $A=\pi\left(R^{2}-r^{2}\right)$, where $R$ is the radius of the larger circle, $r$ is the radius of the smaller circle, and $\pi$ is a constant. Which of the following shows $R$ in terms of $A$ and $r$ ?

A. $R=\sqrt{\frac{A+r^{2}}{\pi}}$
B. $R=\sqrt{\frac{A}{\pi}}+r$
C. $R=\sqrt{\frac{A}{\pi}-r^{2}}$
D. $R=\sqrt{\frac{A}{\pi}+r^{2}}$

## Correct Answer: D Difficult Level: 4

28. $x^{2}+y^{2}+z^{2}=R^{2}$

Using a 3-dimensional coordinate system, the coordinates of a point, $(x, y, z)$, and the polar coordinate, $R$, which is the distance of the point from the origin, can be related by the above equation. Which of the following correctly expresses the $y$-coordinate in terms of the $x$ and $z$-coordinates and the distance, $R$ ?
A. $y=R-x-z$
B. $y=\sqrt{R-x-z}$
C. $y=\sqrt{R^{2}-x^{2}-z^{2}}$
D. $y=\frac{R^{2}-x^{2}-z^{2}}{y}$

Correct Answer: C Difficult Level: 4
29. $E=\frac{A-V}{A}$

The formula above gives the extraction ratio, $E$, of a particular substance by an organ of the body based on the concentration, $A$, of a substance in the blood entering the organ through the arteries and the concentration, $V$, of the substance flowing out of the organ through the veins. Which of the following equations correctly gives the concentration entering through the arteries in terms of the extraction ratio and the concentration leaving through the veins?
A. $A=-V(E-1)$
B. $A=V(E-1)$
C. $A=\frac{V}{1-E}$
D. $A=\frac{V}{E-1}$

Correct Answer: C Difficult Level: 4

## Function notation



1. The graph of $h$ is shown above. If $f(x)=h(-x)$, which of the following represents the graph of $f$ ?
(A)

(B)

©

(D)

2. Let $f(x)=x-1 / x$ and let $g(x)=1 / x$. Assuming $\mathrm{x} x$ does not equal 0 , which of the following is equivalent to $f(g(x))$ ?
A. $\frac{x}{x^{2}-1}$
B. 0
C. $x$
D. $\frac{1}{x}-x$

Correct answer: D LEVEL 2
3. Let $g(x)=8 x-5$. Which of the following is equivalent to $g(g(x))$ ?
A. $64 x-10$
B. $64 x-45$
C. $64 x^{2}+25$
D. $64 x^{2}-80+25$

Correct answer: B LEVEL 2

| $x$ | $f(x)$ | $g(x)$ |
| :---: | :---: | :---: |
| -2 | -6 | -5 |
| -1 | 2 | -2 |
| 2 | 3 | 4 |
| 7 | 7 | 11 |

4. Consider the table shown above. What is the value of $(g \circ f)(-1)$ ?
$\square$
Correct answer: 4 LEVEL 2
5. Consider the graphs of function $f$ and function $g$ shown below.


What is the approximate value of $g(f(5))$ ?
A. 3.5
B. 5
C. 7
D. 9

Correct answer: C LEVEL 2
6. Functions $p(x)$ and $q(x)$ are graphed in the $x y$-plane. The graph $y=p(x)$ is equivalent to the graph $y=q(x)$ reflected over the $\mathrm{x} x$-axis and then reflected over the $y$-axis. Which of the following correctly relates $p(x)$ and $q(x)$ ?
A. $p(x)=q(x)$
B. $p(x)=q(-x)$
C. $p(x)=-q(-x)$
D. $p(x)=-q(x)$

Correct answer: C LEVEL 2

7. The graph of $y=f(x)$ is shown above. If $g(x)=\frac{f(-x)}{2}$, which of the following is the graph of $y=g(x)$


## Correct answer: A LEVEL 2

| $x$ | $f(x)$ |
| :---: | :---: |
| 0 | 2 |
| 1 | 4 |
| 2 | 3 |
| 3 | 1 |
| 4 | 0 |

8. Consider the following table shown above. What is the value of $f(f(4))$ ?
A. 0
B. 1
C. 2
D. 3

Correct answer: C LEVEL 2


1. Consider the graphs of function $f$ and function $g$ shown above. Which of the following could be true?
A. $f(x)=g(x+5)+6$
B. $f(x)=g(x-5)+6$
C. $g(x)=f(x-5)+6$
D. $g(x)=f(x+5)+6$

Correct answer: B LEVEL 3

| $x$ | $f(x)$ | $g(x)$ |
| :---: | :---: | :---: |
| 1 | 1 | 1 |
| 2 | 1 | 3 |
| 3 | 2 | 6 |
| 4 | 3 | 10 |
| 5 | 5 | 15 |
| 6 | 8 | 21 |

2. Consider the table shown above. What is the value of $(f \circ g)(3)$ ?
A. 2
B. 3
C. 6
D. 8

## Correct answer: D LEVEL 3


3. The graph of $y=\sin x$ is shown above. Which of the following is the graph of $y=\sin 3 x$ ?



(D)


Correct answer: A LEVEL 3

4. Consider the graphs of function $f$ and function $g$ shown above. Which of the following could be true?
A. $f(x)=g(-x)-3$
B. $f(x)=g(-x-1)$
C. $f(x)=-g(x)-3$
D. $f(x)=-g(x+2)$

## Correct answer: B LEVEL 3


5. The graph of $y=f(x+2)$ is shown above. For which value of $x$ must $f(x)=4$ ?


6. Consider the graphs of function $f$ and function $g$ shown above. Which of the following best approximates the value of $(g \circ f)(3)$ ?
A. -16.8
B. -2.8
C. 5
D. 9.9

## Correct answer: C LEVEL 3


7. Consider the graphs of function $f$ and function $g$ shown above. What is the value of $g(f(2))$ ?


Correct answer: -6 LEVEL 3
8. The graph of function $f$ can be shifted 4 to the left to obtain the graph of function $g$. If $f(x)=x^{3}$, which of the following is equivalent to function $g$ ?
A. $g(x)=x^{3}-4$
B. $g(x)=x^{3}+4$
C. $g(x)=(x-4)^{3}$
D. $g(x)=(x+4)^{3}$

## Correct answer: D LEVEL 3

9. $Q(x)=\frac{P(2 x)}{2}$

Consider the equation shown above, where $Q$ and $P$ are functions. If $(x 0, y 0)$ is a point on the graph $y=Q(x)$, which of the following is a point on the graph of $y=P(x)$ ?
A. $(x 0, y 0)$
B. $(2 x 0, y 0 / 2)$
C. $(x 0 / 2,2 y 0)$
D. $(2 x 0,2 y 0)$

Correct answer: D LEVEL 3

10. The graphs $y=t(x)$ and $y=u(x)$ are graphed in the $x y$-plane above. Which of the following could be true?
A. $u(x)=-t(2 x)$
B. $u(x)=-t(-2 x)$
C. $u(x)=-t(x / 2)$
D. $u(x)=-t(-x / 2)$

Correct answer: C LEVEL 3

11. The graphs of $y=j(x)$ and $y=k(x)$ are shown above. Which of the following graphs is the graph of $y=j(k(x))$ ?
(A)

(C)

(B)

(D)


## Correct answer: B LEVEL 3

1. Let $h(x)=(x+2) /(x-5)$. Which of the following is equivalent to $h(h(x))$ ?
A. $-\frac{2}{5}, x \neq 5$
B. $\frac{x+4}{x-3}, x \neq 3$ or 5
C. $\frac{3 x-8}{-4 x+27}, x \neq 5$ or $\frac{27}{4}$
D. $\frac{(x+2)^{2}}{(x-5)^{2}}, x \neq 5$

Correct answer: C LEVEL 4
2. Let $f(x)=(2 x-2) /\left(x^{2}+1\right)$ and $g(x)=x^{2}+1$. What is the value of $f(1+g(1))$ ?
$\square$

Correct answer: 2/5 LEVEL 4
3. Let $f(x)=2 x+3$ and let $\mathrm{g}(\mathrm{x})=\mathrm{x}^{\wedge} 2-4 \mathrm{x}$. Which of the following is equivalent to $g(f(x))$ ?
A. $4 x^{\wedge} 2+4 x-3$
B. $4 x^{\wedge} \wedge-8 x-3$
C. $4 x^{\wedge} 2+4 x+21$
D. $2 x^{\wedge} 2-8 x+3$

Correct answer: A LEVEL 4
4. The graph of function $g$ is the graph of function $f$ stretched horizontally by a factor of 2 . Which of the following correctly defines function $g$ ?
A. $g(x)=2 f(x)$
B. $g(x)=(1 / 2) f(x)$
C. $g(x)=f(2 x)$
D. $g(x)=f((1 / 2) x)$

Correct answer: D LEVEL 4
5. Two functions $f$ and $g$ are such that $f(x)=1+2 x$ and $g(f(x))=x+3$. What is the value of $g(5)$ ?


Correct answer: 5 LEVEL 4

Consider the following table.

| $x$ | $f(x)$ | $g(x)$ |
| :---: | :---: | :---: |
| 1 | 2 | 2 |
| 2 | 3 | 2 |
| 3 | 5 | 1 |
| 5 | 6 | 4 |

6. What is the value of $f(g(2))$ ?


## Correct answer: 3 LEVEL 4

7. The graph of $y=f(x)$ can be shifted 3 units in the positive $\mathrm{x} x$-direction and 3 units in the positive $y$-direction to obtain the graph of $y=h(x)$. If $f(x)=4 x+10$ and $h(x)=a x+b$, where $a$ and $b$ are real constants, what must be the value of $b$ ?
$\square$

8. The graph of $y=h(x)$ is shown above. It is true that $f(x)=(1 / 2) h(-x / 2)$. Which of the following represents the graph of $y=f(x)$ ?
(A)

(c)

(B)

(D)


## Correct answer: D LEVEL 4

9. Functions $p(x)$ and $w(x)$ are graphed in the $x y$-plane. The graph of $y=p(x)$ is
equivalent to the graph of $y=w(x)$ translated 4 units upward and 3 units to the left,
where the positive $x$-direction is to the right and the positive $y$-direction is upward.
Which of the following correctly relates $w(x)$ and $p(x)$ ?
A. $w(x)=p(x-3)+4$
B. $w(x)=p(x+3)+4$
C. $w(x)=p(x-3)-4$
D. $w(x)=p(x+3)-4$

## Correct answer: C LEVEL 4


10. The graph of $y=-f(-x)$ is shown above. For which value of $x$ is it true that $f(x)=1$ ?
$\square$

Correct answer: 2 LEVEL 4
11. The graph of function $h$ is the graph of function $g$ stretched vertically by a factor of 3 and reflected over the $y$-axis. Which of the following correctly defines function $h$ ?
A. $h(x)=-3 g(x)$
B. $h(x)=3 g(-x)$
C. $h(x)=g(-3 x)$
D. $h(x)=-g(3 x)$

Correct answer: B LEVEL 4
12. The functions $f(x)$ and $g(x)$ are graphed in the $x y$-plane. The graph of $y=f(x)$ is equivalent to the graph of $y=g(x)$ stretched by a factor of 2 in the $\mathrm{x} x$-direction. If $g(x)=x \cdot e^{x}$, which of the following correctly defines $f(x)$ ?
A. $f(x)=2 x \sqsubset e^{2 x}$
B. $f(x)=2 x \llbracket e^{x}$
C. $f(x)=(x+2) e^{x+2}$
D. $f(x)=0.5 x \sqsubset e^{0.5 x}$

Correct answer: D LEVEL 4

## Ratios, rates and proportions

## LEVEL 3

1. 

Playing tennis
Energy
expenditure
rate

Oxygen
consumption rate $77 \frac{L}{h}$ $130 \frac{L}{h}$

Fat burning rate $49 \frac{g}{h}$

The table above lists average expenditure rates of playing tennis vs. playing squash based on a body weight of 55 kilograms. The ratio of each value in the tennis column to the corresponding value in the squash column is about the same throughout the table. Which of the following is closest to the fat burning rate $r$ of squash?
A. $27 \frac{g}{h}$
B. $29 \frac{g}{h}$
C. $83 \frac{g}{h}$
D. $85 \frac{g}{h}$

Correct answer: C
2. Lea's car travels an average of 30 miles per gallon of gas. If she spent $\$ 20.70$ on gas for a 172.5 mile trip, what was the approximate cost of gas in dollars per gallon?
A. $\$ 1.45$ per gallon
B. $\$ 3.40$ per gallon
C. $\$ 3.60$ per gallon
D. $\$ 5.75$ per gallon

Correct answer: C
3. Kavitha and Andrei are truck drivers for the Delightful Delivery Company, which services cities $W, T$, and $Q$.

The distance from city $W$ to city $T$ is 48.5 miles.
The distance from city $T$ to city $Q$ is 20 miles.
The distance from city $Q$ to city $W$ is 36 miles.

If Kavitha's truck and Andrei's truck travel at the same speed, and it takes Andrei 91 minutes to go from city $W$ to city $T$, about how much time will it take Kavitha to travel from city $W$ to city $Q$ ?
A. 19 minutes
B. 38 minutes
C. 68 minutes
D. 123 minutes

Correct answer: C
4. Yasemin is using a sugar cookie recipe with a flour to sugar ratio of 11:6. To make one batch of cookies, 2.75 cups of flour are needed. If Yasemin would like to triple the recipe, which of the following best approximates how much sugar she will need?
A. 1.5 cups
B. 4.5 cups
C. 5 cups
D. 15 cups

Correct answer: B
5. A certain high school geometry class is made up of freshmen and sophomores. The ratio of freshmen to sophomores in that class is 3:4. If there are 12 sophomores in the class, what is the total number of students in the class?
A. 9
B. 16
C. 21
D. 28

Correct answer: C

## LEVEL 4

1. The musical interval between two sounds is called an "octave" if the ratio of the sounds' frequencies is $2: 1$. The following table shows the names of the musical intervals between two sounds based on the ratios of the two sounds' frequencies.

| Name of the musical interval | Ratio of two sound frequencies |
| :--- | :--- |
| Major third | $4: 5$ |
| Perfect fourth | $3: 4$ |
| Perfect fifth | $2: 3$ |
| Major sixth | $3: 5$ |

If a sound is played with a frequency of 480 Hz , and a second sound is played with a frequency of 800 Hz , what is the name of the musical interval between the two sounds?
A. Major third
B. Perfect fourth
C. Perfect fifth
D. Major sixth

Correct answer: D
2. The "maximum occupancy" of a room is the total number of people who can be in a room without causing a fire hazard. In a large room, a Fire Safety Code states that the maximum occupancy is 1 person for every 7 square feet $\left(f t^{2}\right)$. A college is hosting a concert in a hall that is $14,721 \mathrm{ft}^{2}$, and 1,000 people are expected to attend. According to the Fire Safety Code, approximately how many more people can attend the concert without causing a fire hazard?
A. 900 people
B. 1,000 people
C. 1,100 people
D. 2,100 people

## Correct answer: C

3. A donut company makes cream-filled donuts using $\frac{1}{4} \operatorname{cup}$ (c) of dough and $\frac{1}{2}$ tablespoon (tbsp) of cream per donut. The company decides to change their recipe to use 3 times the amount of cream for their "New Triple-Stuffed Donuts!" If the donut company's new recipe uses the same amount of dough per donut, what is the ratio of dough to cream needed to make 12 triple-stuffed donuts?
A. $1 \mathrm{c}: 3 \mathrm{tbsp}$
B. $1 \mathrm{c}: 6 \mathrm{tbsp}$
C. $2 \mathrm{c}: 3 \mathrm{tbsp}$
D. $1 \mathrm{c}: 2 \mathrm{tbsp}$

Correct answer: B
4. A marine aquarium has a small tank and a large tank, each containing only red and blue fish. In each tank, the ratio of red fish to blue fish is 3 to 4 . The ratio of fish in the large tank to fish in the small tank is 46 to 5 . What is the ratio of blue fish in the small tank to red fish in the large tank?
A. 15:184
B. $10: 69$
C. $69: 10$
D. $184: 15$

Correct answer: B
5. Two leading brands of paper towels are on sale. Brand A has 6 rolls, each with 56 sheets, for $\$ 4.29$. Brand $B$ has 8 rolls, each with 48 sheets, for $\$ 5.99$. Which of the following best describes the relationship between the cost per sheet of the two brands?
A. The two brands cost the same amount per sheet.
B. Brand B costs $\$ 0.003$ more per sheet than Brand A.
C. Brand A costs $\$ 0.003$ more per sheet than Brand B.
D. Brand B costs $\$ 0.03$ more than Brand A.

Correct answer: B

## LEVEL 2

1. Zhang Lei spent $\$ 20.00$ during his last outing at the bowling alley. This included a one time shoe rental fee of $\$ 3.50$. He spent the rest of the money on bowling a number of games. If it took Zhang Lei 45 minutes to bowl each game and he spent 2 hours and 15 minutes bowling, how much did it cost per game?
A. $\$ 3.00$
B. $\$ 5.50$
C. $\$ 6.67$
D. $\$ 7.34$

Correct answer: B Level: 2
2. Mr. Bumble delivers newspapers to his community every week. His route takes 3 hours to complete. During the first 2 weeks of delivering newspapers, he traveled a total of 100 blocks. Mr. Bumble delivers newspapers for 50 weeks each year. How many blocks does Mr. Bumble travel delivering newspapers in 1 year?
A. 1 block
B. 4 blocks
C. 50 blocks
D. 2,500 blocks

Correct answer: D
3. During a timed test, Alexander typed 742 words in 14 minutes. Assuming Alexander works at this rate for the next hour, which of the following best approximates the number of words he would type in that hour?
A. 53
B. 840
C. 3180
D. 44,520

## Correct answer: C

4. 



A quilter wants to make the design shown above using the Golden Ratio.
Specifically, he wants the ratio of the triangle heights $A: B$ and $B: C$ to each equal 1.62. If the quilter makes the triangle height $A=8$ in, approximately how tall should he make triangle height $C$ ?
A. 3 in
B. 4 in
C. 5 in
D. 6 in

## Correct answer: A

5. Elena is conducting a study about the effects of toxins in the water on the hormones of fish. Elena surveys 350 male fish in a river and finds that 150 of the male fish have egg cells growing inside them. According to Elena's survey, what is the ratio of male fish with egg cells to male fish without egg cells in the river?
A. $3: 4$
B. $3: 7$
C. $4: 5$
D. $4: 7$

Correct answer: A

## Percents

1. A college writing seminar increased its size by $50 \%$ from the first to the second day. If the total number of students in the seminar on the second day was 15 , how many students were in the class on the first day?
A. 8
B. 10
C. 23
D. 30

Correct answer: B LEVEL 2

1. In 2005, the USGS conducted a survey to investigate water usage in the United States. The following table shows their findings.

| Categories of water usage | Total estimated water usage |
| :--- | :--- |
| Aquaculture | $2 \%$ |
| Domestic | $1 \%$ |
| Industrial | $4 \%$ |
| Irrigation | $31 \%$ |
| Livestock | $1 \%$ |
| Mining | $1 \%$ |
| Pubic supply | $11 \%$ |
| Thermo electric | $49 \%$ |

If 3.8 billion gallons of water is used for domestic use per day, approximately how many gallons of water are used for irrigation per day?
A. 1 billion
B. 118 billion
C. 152 billion
D. 380 billion

Correct answer: B LEVEL 2
2. A baker at a successful bakery makes three types of cupcakes: vanilla, red velvet, and double chocolate. On Wednesday, he made 18 vanilla cupcakes, which was $17 \%$ of the total amount of cupcakes he made. How many total cupcakes did the baker make on Wednesday?
A. 35
B. 54
C. 94
D. 106

## Correct answer: D LEVEL 2

3. A construction crew was made up of 8 men and the rest women. If $40 \%$ of the crew was comprised of men, how many people were in the crew?


| Sample answers list: |
| :--- |
| an integer, like 6 |
| a simplified fraction number, like $3 / 5$ |
| a simplified improper fraction, like $7 / 4$ |
| an exact decimal, like 0.75 |

Correct answer: 20 LEVEL 2
4. A movie fanatic has amassed a giant collection of home movies, some on DVD and others in the older VHS cassette mode. If the fanatic has 308 movies on DVD, which comprises $31.3 \%$ of the total collection, how many total movies are in the collection?
A. 96
B. 212
C. 676
D. 984

Correct answer: D LEVEL 2
5. A clothing warehouse houses about 14,000 garments at the beginning of each year. Throughout the year, a small percentage of the garments become lost or damaged, and must be replaced at the end of the year. Each year, about $1.5 \%$ of the garments become damaged but not lost, and about $0.6 \%$ become lost. About how many garments must be replaced each year due to loss or damage?
A. 80 garments
B. 130 garments
C. 210 garments
D. 290 garments

Correct answer: D LEVEL 2
6. Mr. Edwards hired a new employee to work in his bakeshop. In one hour, this employee burned 439 chocolate chip cookies, which represented $25 \%$ of all the cookies the employee burned in that day. How many cookies did the new employee burn in the course of the day?
A. 110
B. 351
C. 549
D. 1756

## Correct answer: D LEVEL 2

7. Hailey's laundry basket contains 7 socks. These 7 socks account for approximately $21 \%$ of Hailey's socks. How many socks does Hailey have in total?
A. 2 socks
B. 3 socks
C. 26 socks
D. 33 socks

Correct answer: D LEVEL 2
8. A company has the goal of doubling their revenue from 32 million dollars to 64 million dollars over the next 2 years. If the company increases its revenue by $50 \%$ in the first year, by approximately what percentage must the company increase their revenue in the second year in order to reach their goal?
A. $25 \%$
B. $33 \%$
C. $50 \%$
D. $100 \%$

Correct answer: B LEVEL 2
9. During last year's basketball season, Jackson attempted 150 free throws of which he made 120. So far this season, he's attempted 24 and made 16. A player's free-throw percentage is defined to be the percent of free throws made out of the number of free throws attempted. Assuming calculations began with the start of last year's season, which of the following best approximates Jackson's overall free-throw percentage to date?
A. $67 \%$
B. $73 \%$
C. $78 \%$
D. $80 \%$

Correct answer: C LEVEL 2

1. A store holiday sale has an item marked down by $\$ 10$ with an additional discount of $25 \%$ of the new price. If the final price was $\$ 36.27$, what was the original?
A. $\$ 19.70$
B. $\$ 48.36$
C. $\$ 58.36$
D. $\$ 61.93$

Correct answer: C LEVEL 3
2. A school has $63 \%$ girls and $37 \backslash \% 37 \%$ boys. If $23 \%$ of the girls wears contacts and $42 \%$ of the boys wears contacts, what percent of all students wears contacts?
A. $14.5 \%$
B. $15.5 \%$
C. $30.0 \%$
D. $75.0 \%$

Correct answer: C LEVEL 3
3. Allegra and Simeon were selling containers of cookie dough for a charity event. In the first week, Allegra sold $30 \%$ more than Simeon did. The following week, Allegra sold 12 containers of cookie dough, while Simeon sold none. If Allegra sold $40 \%$ more containers than Simeon did overall, how many did Simeon sell in total?

|  | Sample answers list: |
| :--- | :--- |
|  | an integer, like 6 <br> a simplified fraction number, like 3/5 <br> a simplified improper fraction, like 7/4 <br> an exact decimal, like 0.75 |
| Correct $\quad$ answer: |  |

4. In a community service class in the fall, 3 of the 15 class sessions were lectures, while all others were devoted to fieldwork in parks. In the spring, the number of sessions devoted to fieldwork remained the same, but the total number of sessions increased to 18 . What percent of class sessions were lectures in the spring?
A. $16.7 \%$
B. $33.3 \%$
C. $66.7 \%$
D. $83.3 \%$

## Correct answer: B LEVEL 3

5. On Monday, a fruit vendor bought 80 pieces of fruit to sell at her market, $35 \%$ of which were apples and the rest of which were oranges. On Tuesday, the vendor bought the same number of oranges, but she only bought 73 pieces of fruit. On Tuesday, what percentage of the fruit she bought was apples?
A. $28.8 \%$
B. $38.3 \%$
C. $65.0 \%$
D. $71.2 \%$
6. A student answered 86 problems correctly, which was $81.9 \%$ of the total number of problems on the test. How many problems did the student answer incorrectly?
A. 4
B. 19
C. 86
D. 105

Correct answer: B LEVEL 3
7. Fabrizzio went shopping on Tuesday and decided to purchase a pair of pants that is $15 \%$ off the regular price for the rest of the week. If he buys the pants on Tuesday, he will receive an additional 5\% off. What percent would Tuesday's sale price be of the original price for the pants?
A. $81 \%$
B. $85 \%$
C. $95 \%$
D. $105 \%$

## Correct answer: A LEVEL 3

8. In a college philosophy class during the fall semester, there were 323 students, $42 \%$ of whom were male and the rest of whom were female. In the spring semester, the same number of females was in the class as in the fall, but there were only 298 total students in the class. In the spring, what percent of students were female?
A. $46 \%$
B. $58 \%$
C. $63 \%$
D. $92 \%$

## Correct answer: C LEVEL 3

9. A taxi ride cost a customer a total of $\$ 13.73$, which included $4 \%$ sales tax and then a $\$ 1$ surcharge. What was the subtotal before the surcharge and sales tax?
A. $\$ 0.51$
B. $\$ 12.24$
C. $\$ 13.24$
D. $\$ 318.25$

Correct answer: B LEVEL 3
10. In the United States House of Representatives, $12.2 \%$ of congresspeople are from the State of California. If there are 435 voting congresspeople, how many are not from California?
A. 12.2
B. 53
C. 382
D. 488

Correct answer: C LEVEL 3
11. A chef has a large container of olive oil. In one night, after he used 25 quarts, $35.9 \%$ of the oil remained. How many quarts of olive oil remained in the container?

|  | an integer, like 6 <br> a simplified fraction number, like $3 / 5$ <br> a simplified improper fraction, like $7 / 4$ <br> an exact decimal, like 0.75 |
| :--- | :--- |

Correct answer: 14
LEVEL 3
12. In 2004, the number of people aged 16 years or older in the United States was $223,357,000$. According to the Bureau of Labor Statistics, at that time $66 \%$ of the population aged 16 and older was employed, and women made up about $46.4 \%$ of this category. Approximately how many women aged 16 and older were employed in 2004 ?
A. $68,400,000$
B. $104,000,000$
C. $147,400,000$
D. $157,000,000$

Correct answer: A LEVEL 3

1. At the beginning of the week, Josh had 32 computer games, $133 \%$ as many computer games than Peter had. By the end of the week, Josh gave Peter $25 \%$ of his computer games. How many computer games did Josh and Peter each have by the end of the week?
A. Josh had 8 games; Peter had 24 games.
B. Josh had 24 games; Peter had 8 games.
C. Josh had 24 games; Peter had 32 games.
D. Josh had 32 games; Peter had 24 games.

Correct answer: C LEVEL 4
2. Owen answered a set of math and history Quiz Bowl questions. Owen correctly answered $72 \%$ of all the 200 questions. However, Owen answered $53.3 \%$ of the math questions. If $45 \%$ percent of the questions were in math, what percent of history questions did Owen answer correctly? Round to the nearest percent.

an integer, like 6
a simplified fraction number, like $3 / 5$
a simplified improper fraction, like 7/4 an exact decimal, like 0.75

Correct answer: 87\% LEVEL 4
3. In 2013, the population of Nevada and North Carolina were each growing at a rate of approximately $3.3 \%$ per year. In addition, the US Census Bureau estimated that the population of Nevada and North Carolina was 2.8 million and 9.8 million people, respectively. If the population growth rates in each of these states remained the same, approximately how many more people were living in North

Carolina compared to Nevada in 2014?
A. 7.0 million
B. 7.2 million
C. 9.3 million
D. 13.0 million

Correct answer: B LEVEL 4
4. On Monday, Harry had $75 \%$ as many toys as Teddy did. On Tuesday, after Harry acquired 32 more toys and Teddy acquired $15 \%$ more than he had on Monday, Harry had as many toys as Teddy did. How many toys did Harry have on Monday?

|  | an integer, like 6 <br> a simplified fraction number, like $3 / 5$ <br> a simplified improper fraction, like $7 / 4$ <br> an exact decimal, like 0.75 |
| :--- | :--- |

Correct answer: 60 LEVEL 4
5. The chef has 36 pounds of strip loin steak. The amount of weight lost from the trim on each pound is $35 \%$, and $75 \%$ more of the steak's weight is lost after cooking it. How many pounds of trimmed, cooked strip loin will the chef have left to serve to the customers?
A. 5.85
B. 12.6
C. 17.55
D. 23.4

Correct answer: A LEVEL 4
6. Ivy is downloading a computer program from the Internet. After 8 minutes, the computer program is $35 \%$ downloaded. If the computer program continues to download at the current rate, about how much longer will it take for Ivy's computer to finish downloading the program?
A. 12 minutes
B. 15 minutes
C. 18 minutes
D. 23 minutes

Correct answer: B LEVEL 4
7.

| Baby name | Denis | Dimitri | Lea | Tanya |
| :---: | :---: | :---: | :---: | :---: |
| Frequency | 13 | 27 | 125 | 400 |

The table above displays the number of babies per million babies born in 1985 with each of 4 names. In 1985, about what percentage of babies were named Lea or Dimitri?
A. $0.000152 \%$
B. $0.0152 \%$
C. $0.98 \%$
D. $1.52 \%$

Correct answer: B LEVEL 4
8. A high school's graduation rate is defined to be the percentage of the senior class that graduates. Last year 406 of Sagamore High School's 452 seniors graduated. This year the school expects the previous year's graduation rate to increase by approximately 2 percentage points. If there are 436 students in this year's senior class, which of the following best approximates the number of seniors that Sagamore High School expects to graduate this year?
A. 390 students
B. 400 students
C. 410 students
D. 420 students

Correct answer: B LEVEL 4

## Units

1. While driving with his father, Amit holds his breath whenever they pass through a particular tunnel. Amit counts the number of seconds he holds his breath, from the beginning of the tunnel to the end of the tunnel, and finds that he holds his breath, on average, for about 8 seconds (sec). If his father drives the car at 60 miles per hour through the tunnel, according to the average time Amit hold's his breath, about how long is the tunnel?

Note: There are 5280 feet ( ft ) in 1 mile.
A. 90 ft
B. 700 ft
C. 750 ft
D. 800 ft

## Correct answer: B LEVEL 2

2. A grocery store normally sells lemonade for $\$ 3.50$ per bottle. The grocery store is currently having a sale on lemonade which advertises 6 bottles for only $\$ 13.50$. How much cheaper is the lemonade on sale per bottle compared to the normal price per bottle?
A. $\$ 0.75$
B. $\$ 1.25$
C. $\$ 1.75$
D. $\$ 2.25$

Correct answer: B LEVEL 2
3. João is looking for an apartment to live in. He finds four available apartments. He then records the monthly rent and the size of each apartment in a table, as seen below. Based on the information in the table, which apartment has the highest cost per square foot $\left(f t^{2}\right)$ ?

| Apartments | Rent in dollars | Size in square feet |
| :--- | :--- | :--- |
| Branton Ave. | $\$ 500$ | $400{f t^{2}}^{\text {Dobbs St. }}$ |
| $\$ 600$ | $450 f t^{2}$ |  |
| St. Claire Rd. | $\$ 750$ | $500 f t^{2}$ |
| Woodwick Dr. | $\$ 800$ | $550 f t^{2}$ |

A. Branton Ave.
B. Dobbs St.
C. St. Claire Rd.
D. Woodwick Dr.

Correct answer: C LEVEL 2
4. One study estimated that bears populate the Kenai Peninsula of Alaska at a rate of 42 bears per $1000 \mathrm{~km}^{2}$ of available habitat. According to this study, about how many bears would you expect to find in a habitable region of this peninsula 8500 $\mathrm{km}^{2}$ in size?
A. 24
B. 200
C. 357
D. 3035

## Correct answer: C LEVEL 2

5. The strength of a magnetic field is measured in teslas. One tesla is equal to one weber per square meter, as follows:

$$
1 \mathrm{~T}=1 \frac{W b}{m^{2}}
$$

Divya is building a circuit for her physics class. Point $P$ on one of her wires has a magnetic field strength of $6 \cdot 10^{6}$ webers per square megameter, where 1 megameter is equal to $10^{6}$ meters. What is the magnetic field strength in teslas?
A. $6 \cdot 10^{6}$ teslas
B. $6 \cdot 10^{0}$ teslas
C. $6 \cdot 10^{12}$ teslas
D. $6 \cdot 10^{18}$ teslas

Correct answer: A LEVEL 2

1. In August 2009, Usain Bolt ran 100 meters in 9.58 seconds (sec), setting the world record at that time. There are approximately 1.094 yards (yd) in a meter. What was Usain Bolt's average speed in yards per second?
A. $9.54 \frac{y d}{s e c}$
B. $9.58 \frac{y d}{s e c}$
C. $10.44 \frac{y d}{s e c}$
D. $11.42 \frac{\mathrm{yd}}{\mathrm{sec}}$

## Correct answer: D LEVEL 3

2. According to the United States Census Bureau, on September 1, 2014, the population of the United States was increasing by 1 person every 12 seconds. At this rate, by how much would the population of the United States increase in 1 year?
A. 43,800
B. 525,600
C. $2,628,000$
D. $31,536,000$

Correct answer: C LEVEL 3
3. Grace examines two different size bottles of the same laundry detergent. The price for the 100 -ounce bottle is $\$ 9.99$ and the price for the 150 -ounce bottle is $\$ 12.99$. How much money will Grace save per 100 ounces if she purchases the larger bottle?
A. $\$ 0.01$
B. $\$ 1.33$
C. $\$ 2.00$
D. $\$ 8.66$

Correct answer: B LEVEL 3
4. An ancient Chinese candle clock tells the amount of time that has passed by the amount of wax that has been melted off the candle. Each candle is divided into 12 sections, marked 1 inch (in) apart. It takes 4 hours (hrs) for each candle to completely melt, after which a new candle is lit. If two candles have completely melted and one candle has melted 4 in, how many minutes have passed since the first candle was lit?
A. 480 minutes
B. 500 minutes
C. 560 minutes
D. 600 minutes

Correct answer: C LEVEL 3
5. Which of the following cities had the largest population density in 2010 ?
(Population density is defined to be the number of people per square mile.)

| City | 2010 census population | Area (in square miles) |
| :--- | :--- | :--- |
| Boston | 645,149 | 48.43 |
| Chicago | $2,695,598$ | 227.13 |
| Miami | 362,470 | 35.67 |
| Philadelphia | $1,517,550$ | 135.09 |

A. Boston
B. Chicago
C. Miami
D. Philadelphia

Correct answer: A LEVEL 3

1. Dr. Li Jie measures the absorption of radiation coming from his X-ray device to be $5 \cdot 10^{-18}$ square centimeters per square nanosecond but needs to report the finding in "grays", where grays are equivalent to square meters per square second. If there are $10^{9}$ nanoseconds in a second, what is the absorption of radiation in grays?
A. $5 \cdot 10^{40}$ grays
B. $5 \cdot 10^{31}$ grays
C. $5 \cdot 10^{11}$ grays
D. $5 \cdot 10^{4}$ grays

Correct answer: D LEVEL 4
2. When traveling in France, Joe purchased gas which cost 1.45 euros per liter. If at the time of the purchase 1 euro was worth $\$ 1.35$, what was the approximate cost, in dollars, of one gallon of gas?

Note: 1 gallon is approximately 3.785 liters.
A. $\$ 0.52$
B. $\$ 3.52$
C. $\$ 4.07$
D. $\$ 7.40$

Correct answer: D LEVEL 4
3. The apparent brightness of a surface, in "lux", is found by measuring the energy of the light coming from the source and dividing by the area of the surface. Lux are equivalent to candelas per square meter. Abigail is building a new type of television screen and measures the brightness of glare to be 0.0002 kilocandelas per square centimeter. What is the brightness of glare expressed in lux?
A. 0.00002 lux
B. 0.002 lux
C. 20 lux
D. 2,000 lux

Correct answer: D LEVEL 4
4. In 2012, an 11-year-old cheetah set a new record by running 100 meters in 5.95 seconds. During this record-breaking run, at what approximate speed was the cheetah traveling in miles per hour?

Note: There are 1.6 kilometers in 1 mile.
A. 16.81 miles per hour
B. 34.27 miles per hour
C. 37.82 miles per hour
D. 60.50 miles per hour

## Correct answer: C LEVEL 4

5. A generator produces $6.5 \times 10^{2}$ kilojoules per centisecond $\left(\frac{k J}{c s}\right)$. A watt is equivalent to 1 joule per second $\frac{J}{S}$. What is the measured power of the generator in watts?
A. $6.5 \times 10^{7}$ watts
B. $6.5 \times 10^{3}$ watts
C. $6.5 \times 10^{1}$ watts
D. $6.5 \times 10^{3}$ watts

Correct answer: D LEVEL 4

## Table data

1. A donut company makes cream-filled donuts using $1 / 4$ cup (c) of dough and $1 / 2$ tablespoon (tbsp) of cream per donut. The company decides to change their recipe to use 3 times the amount of cream for their "New Triple-Stuffed Donuts!" If the donut company's new recipe uses the same amount of dough per donut, what is the ratio of dough to cream needed to make 12 triple-stuffed donuts?
A. $1 \mathrm{c}: 3 \mathrm{tbsp}$
B. $1 \mathrm{c}: 6$ tbsp
C. $2 \mathrm{c}: 3 \mathrm{tbsp}$
D. $1 \mathrm{c}: 2 \mathrm{tbsp}$

Correct Answer : B Level : 1
2. Mr. Bumble delivers newspapers to his community every week. His route takes 3 hours to complete. During the first 2 weeks of delivering newspapers, he traveled a total of 100 blocks. Mr. Bumble delivers newspapers for 50 weeks each year. How many blocks does Mr. Bumble travel delivering newspapers in 1 year?
A. 1 block
B. 4 blocks
C. 50 blocks
D. 2,500 blocks

Correct Answer: D Level : 1

| Time period | Fewer than <br> 100 pages | $100-499$ <br> pages | 500 or more <br> pages | Total |
| :--- | ---: | ---: | ---: | ---: | ---: |
| Old/Middle <br> English | 1 | 2 | 2 | 5 |
| Neo- <br> classical | 0 | 1 | 2 | 3 |
| $19^{\text {th }}$ century | 1 | 7 | 6 | 14 |
| $20^{\text {th }}$ century | 1 | 0 | 2 | 3 |
| Total | 3 | 10 | 12 | 25 |

1. Several English professors categorized the literary works from their seminars by time period and length as shown in the table at the left. According to the table, what percentage of those books with 500 or more pages are from the 19th century?
A. $17 \%$
B. $43 \%$
C. $50 \%$
D. $56 \%$

Correct answer: C LEVEL 2

| Preferred Sport | $10^{\text {th }}$ graders | $11^{\mathrm{th}}$ graders | Total |
| :--- | ---: | ---: | ---: | :--- |
| Football | 30 |  |  |
| Basketball | - | - | - |
| Total | - | - | 136 |
|  |  | 166 | - |

2. Guilherme asked 10th and 11th graders at his school which sport they preferred between basketball and football. The table above partially shows the results. Given that $20 \%$ of students in Guilherme's school who prefer football are in 10th grade, how many 11th graders at his school prefer basketball?
A. 27
B. 46
C. 120
D. 150

Correct answer: B LEVEL 2

| Chapter | Skills problems | Analysis problems | Total |
| :--- | ---: | ---: | ---: |
| Chapter 1 | 11 | 12 | 23 |
| Chapter 2 | 10 | 11 | 21 |
| Chapter 3 | 6 | 12 | 18 |
| Chapter 4 | 23 | 4 | 27 |
| Total | 50 | 39 | 89 |

3. A science textbook has four chapters, each with a number of skills problems and of analysis problems. A table representing this information is on the left. Based on the table, which of the following statements is true?
A. The relative frequency of analysis problems coming from chapter 4 is $\frac{4}{39}$.
B. The relative frequency of analysis problems coming from chapter 2 is $\frac{21}{89}$.
C. The relative frequency of problems in chapter 1 being skills problems is $\frac{12}{23}$.
D. The relative frequency of problems in chapter 2 being skills problems is $\frac{2}{3}$.

|  | On time | Late | Total |
| :--- | :---: | :---: | :---: |
| Route A | 5 | 6 | 11 |
| Route B | 2 | 10 | 12 |
| Route C | 6 | 11 | 17 |
| Total | 13 | 27 | 40 |

4. Victor decides to try three different routes to work for a period of 40 days. In the table above, he tracked whether he arrived to work late or on time each time that he used a particular route. According to the table, what is the probability that Victor was late when he used Route A?
A. $\frac{3}{20}$
B. $\frac{2}{9}$
C. $\frac{3}{5}$
D. $\frac{6}{11}$

Correct answer: D LEVEL 2

| Enrollment trends in biological focused programs |
| :--- |
|  |
|  |
| Bioinformatics |


| Forensics | Pre-Med | Total |  |  |
| :--- | :--- | ---: | :--- | :--- |
| Male |  | - | - | 310 |
| Female | - | - | - | 381 |
| Total | 97 | 214 | 380 | 691 |

5. A biology professor is investigating trends in current enrollment of male/female undergraduate students in certain biologically focused cross-departmental programs. The above table represents the professor's findings. Note that students are not allowed to enroll in more than one of these programs at this particular school. About how many female students should be enrolled in the forensics program to provide evidence that enrolling in forensics is independent of student gender?
A. 66
B. 118
C. 210
D. 214

Correct answer: B LEVEL 2

| House Construction in the Historic District |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Poured Concrete | Field stone \& mortar | Combination | Total |
| Historically-protected | 0 | - | - | 205 |
| Non-historicallyprotected | - | - | 18 | 134 |
| Total | - | 203 | - | 339 |

6. The houses in the "historic district" of a particular town are either historically protected or not. The above table partially represents these homes and whether they have foundations made from poured concrete, mortar and field stone, or a combination of both. If only $4.5 \%$ of the non-historically-protected homes have a field stone \& mortar foundation, how many homes is this? Round to the nearest whole number.

## Correct answer: $6 \pm 0.5$ LEVEL 2

|  | Red | Blue | Total |
| :--- | ---: | ---: | ---: |
| Triangles | 1 | 3 | 4 |
| Quadrilaterals | 2 | 6 | 8 |
| Pentagons | 5 | 7 | 12 |
| Total | 8 | 16 | 24 |

1. Geometry students participated in an activity to classify the shapes in the room by number of sides and color. The table above displays the results. If a triangle is chosen at random from this activity, what is the probability that it is blue?
A. $\frac{3}{16}$
B. $\frac{1}{8}$
C. $\frac{1}{2}$
D. $\frac{3}{4}$

Correct answer: D LEVEL 3

| Chapter | Skills problems | Analysis problems | Total |
| :--- | ---: | ---: | ---: |
| Chapter 1 | 11 | 12 | 23 |
| Chapter 2 | 10 | 11 | 21 |
| Chapter 3 | 6 | 12 | 18 |
| Chapter 4 | 23 | 4 | 27 |
| Total | 50 | 39 | 89 |

2. A science textbook has four chapters, each with a number of skills problems and of analysis problems. A table representing this information is on the left. Based on the table, which of the following statements is true?
A. The relative frequency of analysis problems coming from chapter 4 is $\frac{4}{39}$.
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C. The relative frequency of problems in chapter 1 being skills problems is $\frac{12}{23}$.
D. The relative frequency of problems in chapter 2 being skills problems is $\frac{2}{3}$.

| Population of country in North and Central America | Fewer than 100 per $\mathrm{km}^{2}$ | $\begin{array}{r} 100-199 \\ \text { per km² } \end{array}$ | $\begin{array}{r} 200 \\ \text { per } \\ \mathrm{km}^{2} \text { or } \\ \text { greater } \end{array}$ | Total |
| :---: | :---: | :---: | :---: | :---: |
| Small population (Less than $1,000,000$ ) | - | - | - | 9 |
| Medium population $(1,000,000-19,999,999)$ | - |  |  | 11 |
| Large population (20,000,000 and greater) | - | - | - | 3 |
| Total | - | - | - | - |

3. Students in a college geography class created a table in which the countries of North and Central America are displayed by both population and population density (per square kilometer). If the relative frequency of this occurring compared with all countries in North America is 0.174 , how many countries have a population density of fewer than 100 per $\mathrm{km}^{2}$ and have a medium population?
A. 2
B. 4
C. 17
D. 63

## Correct answer: B LEVEL 3

|  | Rice | Pasta | Total |
| :--- | ---: | ---: | ---: |
| Beef | 4 | 6 | 10 |
| Chicken | 20 | 5 | 25 |
| Total | 24 | 11 | 35 |

4. A group of restaurant owners surveyed a list of people to determine how preferences of meats compared to preferences of grains, and if they are related. The results are in the table above. Based on the table, is there evidence of association between chicken preferences and rice preferences?
A. Yes, because the proportion of chicken and rice eaters to all chicken eaters is higher than all rice eaters to all eaters; and because the proportion of chicken and rice eaters to all rice eaters is higher than all chicken eaters to all eaters.
B. Yes, because the proportion of chicken and rice eaters to all rice eaters is higher than all rice eaters to all eaters; and because the proportion of chicken and rice eaters to all rice eaters is higher than all rice eaters to all eaters.
C. No, because the proportion of chicken and rice eaters to all chicken eaters is lower than all rice eaters to all eaters; and because the proportion of chicken and rice eaters to all rice eaters is lower than all chicken eaters to all eaters.
D. No, because the proportion of chicken and rice eaters to all chicken eaters is lower than all chicken eaters to all eaters; and because the proportion of chicken and rice eaters to all rice eaters is lower than all rice eaters to all eaters.

## Correct answer: A LEVEL 3

|  | On time | Late | Total |
| :--- | :---: | :---: | :---: |
| Route A | 5 | 6 | 11 |
| Route B | 2 | 10 | 12 |
| Route C | 6 | 11 | 17 |
| Total | 13 | 27 | 40 |

5. Victor decides to try three different routes to work for a period of 40 days. In the table above, he tracked whether he arrived to work late or on time each time that he used a particular route. According to the table, what is the probability that Victor took late when he used Route A?
A. $\frac{3}{20}$
B. $\frac{2}{9}$
C. $\frac{3}{5}$
D. $\frac{6}{11}$

Correct answer: D LEVEL 2

| Telecommuting in the US job market |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Sales | Computer Programming | Other | Total |
| 100\% Remote |  | 185 | 247 | 179 | 611 |
| 100\% On-Site |  | 1918 | 1837 | 1364 | 5119 |
| Partially Remote | ( $>20 \%$ remote) | 1012 | 743 | 930 | 2685 |
| Total |  | 3115 | 2827 | 2473 | 8415 |

6. A survey conducted on a random sample reports findings on telecommuting in non-academic jobs in the United States, with a focus on sales and computer programming. According to the table above, what is the probability that a randomly chosen job from the study is a partially remote sales job? Round to the nearest hundredth.


Correct answer: 0.12 LEVEL 3

| Plastic Products and BPA Content |  |  |  |
| :--- | ---: | ---: | ---: |
|  | Epoxy Resin | Polycarbonate | Total |
| contains BPA | 133 | 258 | 391 |
| does not contain BPA | 64 | 44 | 108 |
| Total | 197 | 302 | 499 |

7. A manufacturer of plastics and epoxy resins has committed to eliminating the chemical Bisphenol-A (BPA) from its entire product line. According to the table, what percentage of the manufacturer's epoxy resin and polycarbonate products are BPA-containing polycarbonate products? Round answer to the nearest tenth of a percent.

Correct answer: 51.7 $\pm 0.1$ LEVEL 3

|  | Red | Blue | Total |
| :--- | ---: | ---: | ---: |
| Triangles | 1 | 3 | 4 |
| Quadrilaterals | 2 | 6 | 8 |
| Pentagons | 5 | 7 | 12 |
| Total | 8 | 16 | 24 |

8. Geometry students participated in an activity to classify the shapes in the room by number of sides and color. The table above displays the results. If a triangle is chosen at random from this activity, what is the probability that it is blue?
A. $\frac{3}{16}$
B. $\frac{1}{8}$
C. $\frac{1}{2}$
D. $\frac{3}{4}$

Correct answer: D LEVEL 3

| Chapter | Skills problems | Analysis problems | Total |
| :--- | ---: | ---: | ---: |
| Chapter 1 | 11 | 12 | 23 |
| Chapter 2 | 10 | 11 | 21 |
| Chapter 3 | 6 | 12 | 18 |
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| Population of country in North and Central America | $\begin{gathered} \text { Fewer } \\ \text { than } \\ 100 \\ \text { per } \\ \mathrm{km}^{2} \end{gathered}$ | $\begin{array}{r} 100-199 \\ \text { per } \mathrm{km}^{2} \end{array}$ | $\begin{array}{r} 200 \\ \text { per } \\ \mathrm{km}^{2} \text { or } \\ \text { greater } \end{array}$ | Total |
| :---: | :---: | :---: | :---: | :---: |
| Small population (Less than $1,000,000$ ) | - | - | - | 9 |
| Medium population ( $1,000,000-19,999,999$ ) |  | - | - | 11 |
| Large population <br> (20,000,000 and greater) | - | - | - | 3 |
| Total | - | - | - | - |

10. Students in a college geography class created a table in which the countries of North and Central America are displayed by both population and population density (per square kilometer). If the relative frequency of this occurring compared with all countries in North America is 0.174 , how many countries have a population density of fewer than $100 \mathrm{~km}^{2}$ and have a medium population?
A. 2
B. 4
C. 17
D. 63

Correct answer: B LEVEL 3

|  | On time | Late | Total |
| :--- | :---: | :---: | :---: |
| Route A | 5 | 6 | 11 |
| Route B | 2 | 10 | 12 |
| Route C | 6 | 11 | 17 |
| Total | 13 | 27 | 40 |

1. Victor decides to try three different routes to work for a period of 40 days. In the table above, he tracked whether he arrived to work late or on time each time that he used a particular route. According to the table, what is the probability that Victor took late when he used Route A?
A. $\frac{3}{20}$
B. $\frac{2}{9}$
C. $\frac{3}{5}$
D. $\frac{6}{11}$

Correct answer: B LEVEL 4

| Language | Native speakers | Non-native speakers | Total |
| :--- | ---: | ---: | ---: |
| Mandarin Chinese | 848 | 178 | 1026 |
| Spanish | 415 | - | - |
| Hindi | 400 | 200 | 600 |
| English | 335 |  | - |
| Arabic | 485 | 145 | 625 |
| Total | 2483 | 1237 | 3570 |

2. The table on the left shows the most commonly spoken five languages in the world by native and non-native speakers, in millions, according to the 2013 SIL Ethnologue. If the relative frequency of Spanish non-native speakers to all non-native speakers was $4.8 \%$, approximately how many non-native Spanish speakers, in millions, were there in 2013?
A. 20
B. 59
C. 119
D. 594

Correct answer: B LEVEL 4

|  | Cheese | No cheese | Total |
| :--- | ---: | ---: | ---: |
| Sauce | - |  | 18 |
| No sauce | - | - | 8 |
| Total | 20 | 6 | 26 |

3. Donte and his friends ordered pizza for a birthday party. They asked all the guests at the party whether they wanted sauce or no sauce and whether they wanted cheese or no cheese. The results are displayed in the table above.

Donte found that $1 / 5$ of the people who wanted cheese did not want sauce.
What fraction of the people who wanted sauce also wanted cheese?
A. $1 / 9$
B. $8 / 13$
C. $4 / 5$
D. $8 / 9$

Correct answer: D LEVEL 4

|  | Fewer than 200 pages | 200 pages and above | Total |
| :--- | ---: | ---: | ---: |
| $19^{\text {th }}$ century |  |  |  |
| $20^{\text {th }}$ century | 4 | 14 |  |
| Total |  | 20 |  |

4. An English professor classified the novels in his British Literature syllabus by century written and length of the novel. Some of the results are in the table above. Based on the table, how many books, both from 20th century that are 200 pages and above, could there be in the class to suggest evidence of association?


Correct answer: 12 LEVEL 4

|  | $10^{\text {th }}$ | $11^{\text {th }}$ | Total |
| :--- | :--- | :--- | :--- |
| Football | - | 12 | - |
| Basketball | 14 | - | - |
| Total | - | - | 156 |

5. Ori asked 10th and 11th graders at his school which sport they preferred between basketball and football. The table above partially shows the results. Given that $40 \%$ of 10th graders at his school prefer basketball, how many 10th graders at his school prefer football?
$\square$

Correct answer: 21 LEVEL 4

|  | Cheese | No cheese | Total |
| :--- | ---: | ---: | ---: |
| Sauce | - | - | 18 |
| No sauce | - | - | 8 |
| Total | 20 | 6 | 26 |

6. Donte and his friends ordered pizza for a birthday party. They asked all the guests at the party whether they wanted sauce or no sauce and whether they wanted cheese or no cheese. The results are displayed in the table above.

Donte found that $1 / 5$ of the people who wanted cheese did not want sauce. What fraction of the people who wanted sauce also wanted cheese?
A. $1 / 9$
B. $8 / 13$
C. $4 / 5$
D. $8 / 9$

Correct answer: D LEVEL 4

## Scatterplots



1. The scatterplot to the left displays the percentage, $P$, of paper consumed in the United States (US) that has been recycled from 1990 to 2012, where $t$ represents years since 1990. Which of the following equations best models the relationship between years since 1990 and the percent of consumed paper that has been recycled?
A. $P=0.8 t+35$
B. $P=1.3 t+35$
C. $P=1.7 t+35$
D. $P=3 t+35$

Correct answer: B LEVEL 2

2. Adsila monitored gas prices at her local gas station throughout 2014. The scatterplot to the left shows the price, $g$, in dollars, for 1 gallon of gas on various days of the year, where $d$ represents days since January 1, 2014. A function that models the data is shown on the graph. Which of the following best approximates the price for 1 gallon of gas on September 12, 2014, the $255^{\text {th }}$ day of the year?
A. $\$ 2.55$
B. $\$ 3.10$
C. $\$ 3.45$
D. $\$ 3.50$

Correct answer: D LEVEL 2

3. The scatterplot to the left shows the number of moose $M$, estimated to be living in Minnesota from 2005 to 2012. Which of the following equations best models the population of moose in Minnesota during this time period, where $t$ represents the years since 2005?
A. $M=8,593-563 t$
B. $M=10,343-1,842 t$
C. $M=7,923+578 t$
D. $M=5,725+467 t$

Correct answer: A LEVEL 2

4. The scatter plot drawn at left depicts the price of 1 gallon of gasoline in the United States (U.S.) from 1980 to 2008. The graph of a quadratic model that fits this data has a vertex at $(17.24,1.33)(17.24,1.33)$. What does the vertex tell us about U.S. gas prices?
A. In the year 1997, the price for 1 gallon of gasoline reached its exact maximum value of $\$ 1.33$.
B. In the year 1997, the price for 11 gallon of gasoline reached its exact minimum value of $\$ 1.33$.
C. In approximately the year 1997, the price for 1 gallon of gasoline reached its approximate maximum value of $\$ 1.33$.
D. In approximately the year 1997, the price for 11 gallon of gasoline reached its approximate minimum value of $\$ 1.33$.

Correct answer: D LEVEL 2

5. During the 2014-2015 season, a statistician collected data on a professional sports team. The scatterplot to the left shows his findings for the average minutes played per game and the average points scored per game for each player on the team. Which of the following equations best relates minutes played per game, $x$, and points scored per game, $p$, for players on this team?
A. $p=2 x-2$
B. $p=2 x+3$
C. $p=0.5 x-2$
D. $p=0.5 x+3$

6. The scatter plot drawn at left depicts the change in the number of women in the United States Congress from 1970 to 2009. Which of the following is the best exponential model for this data?
A. $f(x)=1.056(12.590)^{x}$
B. $f(x)=12.590(0.106)^{x}$
C. $f(x)=12.590(1.056)^{x}$
D. $f(x)=125.90(1.056)^{x}$

7. The scatter plot drawn at the left depicts the percentage of Maryland residents born in Maryland between the years 1900 and 2000. Which of the following equations best describes the relationship shown?
A. $y=-0.3 x+78.7$
B. $y=3.3 x-78.7$
C. $y=-0.3 x-78.7$
D. $y=-3.3 x+78.7$

Correct answer: A LEVEL 2

8. The scatterplot to the left shows the number of college students, $n$, in millions, who enrolled in at least one online-course from 2002 to 2011, where $t$ represents years since 2002. A best fit line that approximates the data is also shown on the scatterplot. Which of the following is closest to the yearly increase in online college student enrollment from 2002 to 2011 ?
A. 130,000
B. 580,000
C. $1,725,000$
D. $58,000,000$

Correct answer: D LEVEL 2

Mateus calculated his car's average fuel economy, $y$, in miles per gallon (mpg), for various speeds, $x$, in miles per hour ( mph ), and recorded his data, along with a best fit curve, on the scatter plot below.

9. Based on the model, which of the following is a true statement?
A. Mateus' car gets a maximum fuel economy of approximately 46 mpg .
B. Mateus' car obtains its maximum fuel economy when traveling approximately 46 mph .
C. The car's fuel economy increases by approximately 46 mpg as it accelerates from 0 mph to 70 mph .
D. Mateus' car has a fuel economy of approximately 46 mpg regardless of the speed.

Correct answer: B LEVEL 2

10. The scatterplot to the left depicts the amount of copper, $c$, in metric tons, produced in the world from 1900 to 2010, where $t$ is years since 1900. Which of the following best approximates the world copper production, in metric tons, in 1995?
A. 0.5
B. 9
C. 11
D. 13

Correct answer: C LEVEL 2


1. The weight and fuel economy for various vehicles were measured and recorded in the scatterplot to the left. Given that $w$ represents the weight of the vehicle, in thousands of pounds (lbs), and $f$ represents the fuel economy, in miles per gallon ( mpg ), which of the following equations best models the relationship between $f$ and $w$ ?
A. $f=50-0.1 w$
B. $f=50-9.8 w$
C. $f=65.7-0.1 w$
D. $f=65.7-9.8 w$

Correct answer: D LEVEL 3

Miles conducted an experiment to determine if there was a connection between a person's age and the person's typing rate. During the experiment, all subjects were asked to type the same essay. Their age, $a$, and typing rate $r$, in words per minute, were recorded in the scatterplot below.

2. According to the experiment, which of the following equations best models the relationship between age and typing rate?
A. $r=-0.88 a+67$
B. $r=-0.88 a+103$
C. $r=-1.15 a+94$
D. $r=-1.15 a+108$

Correct answer: D LEVEL 3

3. The scatterplot to the left shows the temperatures, $y$, in degrees Celcius $\left({ }^{\circ} \mathrm{C}\right)$, of a cup of coffee cooling in a $22^{\circ} \mathrm{C}$ room at 5 minute intervals. If $x$ represents the time, in minutes, since the coffee had a temperature of $92^{\circ} \mathrm{C}$, which of the following could be used to predict the temperature of the coffee for $0 \leq x \leq 60$ ?
A. $y=92-9.25 x$
B. $y=92-22 x$
C. $y=92(0.925)^{x}$
D. $y=70(0.925)^{x} x+22$

Correct answer: D LEVEL 3

4. The scatterplot to the left shows average 2014 Major League Baseball (MLB) salaries, $y$, in millions of dollars, for players $x$ years of age. Which of the following quadratic equations best models the relationship between a MLB player's age and his salary?
A. $y=0.1(x-23.1)^{2}+0.78$
B. $y=0.1(x+23.1)^{2}+0.78$
C. $y=2(x-23.1)^{2}+0.78$
D. $y=2(x+23.1)^{2}+0.78$

Correct answer: A LEVEL 3

5. The scatterplot to the left shows the population of North Dakota, $p$, in thousands, from 2000 to 2014. Which of the following is the best quadratic model for the North Dakota population, where $t$ is the number of years since 2000?
A. $p=0.78(t-2.8)^{2}+638.4$
B. $p=0.78(t+2.8)^{2}+638.4$
C. $p=0.78(t-638.4)^{2}+2.8$
D. $p=0.78(t+638.4)^{2}+2.8$

Correct answer: A LEVEL 3

6. The scatter plot drawn at left depicts the concentration of antibiotics in a patient's blood over time. Which of the following functions best describes the relationship shown?
A. $f(x)=22.45 x^{2}+92.38 x+1.86$
B. $f(x)=-22.45 x^{2}+92.38 x+1.86$
C. $f(x)=1.86(22.45)^{x}$
D. $f(x)=22.45(1.86)^{x}$

Correct answer: B LEVEL 3

7. The scatterplot to the left depicts the net sales revenue, $R$, in billions of dollars, for a major online retailer from 2004 to 2014. If $t$ is years since 2004, which of the following best approximates the percent by which the net sales revenue for this company increased each year from 2004 to 2014 ?
A. $2 \%$
B. $3 \%$
C. $10 \%$
D. $30 \%$

Correct answer: D LEVEL 3

A digital photographer experimented with her hourly pricing for a year. She changed her hourly rate each month and recorded her corresponding monthly earnings. The scatterplot below shows the monthly earnings, $M$, in dollars, for one year.

8. Which of the following equations best models the relationship between the photographer's hourly rate, $r$, and her monthly earnings?
A. $M=-6.36(r-89)^{2}+8400$
B. $M=-6.36(r+89)^{2}+8400$
C. $M=6.36(r-89)^{2}+8400$
D. $M=6.36(r+89)^{2}+8400$

Correct answer: A LEVEL 3

9. Each year from 2007 to 2015, Americans were surveyed regarding their use of online radio. The survey asked Americans to report whether or not they listened to online radio in the last month. The scatterplot to the left shows the results of the survey, where $P$ represents the percent of respondents who reported listening to online radio and $t$ represents years since 2007. Which of the following best models the relationship between $t$ and $P$ ?
A. $P=t+20$
B. $P=2.3 t+20$
C. $P=0.23 t+18$
D. $P=4.3 t+18$

Correct answer: D LEVEL 3

10. The scatterplot to the left shows the cost, $C$, in thousands of dollars, and living space, $x$, in square feet $\mathrm{ft}^{2}$ for several houses in a certain neighborhood. According to the data, which of the following best approximates the cost for an additional square foot of living space for homes in this neighborhood?
A. $\$ 80$
B. $\$ 300$
C. $\$ 1,000$
D. $\$ 13,000$

11. The scatterplot to the left shows the number, $N$, in millions, of rock albums sold in the United States (US) from 2008 to 2014. A line of best fit is shown on the graph. According to the model, if this trend continues, which of the following best predicts the number of rock albums sold in the US in $2016 ?$
A. 8 million
B. 68 million
C. 83 million
D. 130 million

Correct answer: B LEVEL 3

12. The scatterplot to the left shows the price, $c$, per troy ounce of gold in United State's (US) dollars from 1996 to 2011, where $t$ represents years since 1996. Which of the following equations best models the data?
A. $c=50(1.25)^{t}$
B. $c=400(0.85)^{t}$
C. $c=10.34(\mathrm{t}-4.14)^{t}+245$
D. $c=10.34(\mathrm{t}-245)^{t}+4.14$

Correct answer: C LEVEL 3

13. The scatter plot to the left shows the number of times, $s$, in thousands, a video has been shared on a given day, $t$, after the video was initially shared. If the exponential function that best models the data is shown above, which of the following best describes the percent by which the number of shares increased each day?
A. $5 \%$
B. $10 \%$
C. $18 \%$
D. $40 \%$

Correct answer: D LEVEL 3

14. Jude sees the scatterplot to the left relating altitude and temperature in his meteorology textbook. Given that $x$ stands for altitude, in thousands of feet ( ft ), and $y$ stands for temperature, in degrees Fahrenheit, $(\circ \mathrm{F})$, which of the following statements is the best interpretation for the slope of the line of best fit in this situation?
A. The temperature decreases by about $3.5 \circ \mathrm{~F}$ for every 1 ft of elevation gain.
B. The temperature decreases by about $1 \circ \mathrm{~F}$ for every 3.5 ft of elevation gain.
C. The temperature decreases by about $3.5 \circ \mathrm{~F}$ for every 1000 ft of elevation gain.
D. The temperature decreases by about $1000 \circ \mathrm{~F}$ for every 3.5 ft of elevation gain.

Correct answer: C LEVEL 3

15. The scatterplot to the left shows the number of calories a 130 -pound individual burns during a 1-hour bike ride at various speeds. For $s \geq 5$, which of the following best models the relationship between $s$ and $C$, where $s$ represents the speed of the rider, in miles per hour (mph), and $C$ represents the total calories burned?
A. $C=59 s+5$
B. $C=59 s-295$
C. $C=295-59 s$
D. $C=5-59 s$

Percentage of American adults that use the internet, $(y)$

16. The scatter plot at left shows the different percentages of Americans that reported using the internet in the years 1995 to 2014. Based on the line of best fit to the data shown, which of the following values is closest to the average yearly change in the percentage of American adults that use the internet?
A. 0.27 percent
B. 1.01 percent
C. 3.71 percent
D. 1.33 percent

Correct answer: C LEVEL 3

17. The scatterplot to the left shows the latitudes of various United States (US) cities plotted against the city's average September temperature, where $l$ is the latitude of the city, in degrees, and $T$ is the city's average September temperature, in degrees Farenheit $\left({ }^{\circ} \mathrm{F}\right)$. A line that approximates the data is shown on the graph. Which of the following statements is the best interpretation for the slope of the line of best fit in this situation?
A. The average September temperature for a US city decreases by 2 for each 3 degree increase in latitude.
B. The average September temperature for a US city increases by 2 for each 3 degree increase in latitude.
C. The average September temperature for a US city decreases by 3 for each 2 degree increase in latitude.
D. The average September temperature for a US city increases by $3^{\circ} \mathrm{F}$ for each 2 degree increase in latitude.

Correct answer: C LEVEL 3

18. The scatter plot drawn at left depicts the average monthly temperatures in degrees Fahrenheit in Chicago, Illinois during the year 2013. Which of the following functions best describes the relationship shown?
A. $f(x)=1.67 x^{2}-23.04 x-2.86$
B. $f(x)=-1.67 x^{2}+23.04 x-2.86$
C. $f(x)=25.91\left(1.03^{x}\right)$
D. $f(x)=15.91\left(0.97^{x}\right)$

Correct answer: B LEVEL 3

19. A clinic recorded age and bone mineral density for several of its patients in the scatter plot to the left. Given that $x$ represents the age of the patient, in years, and $y$ represents the bone mineral density, in grams per square centimeter $\left(\frac{g}{c m^{2}}\right)$, which of the following equations best models the data?
A. $y=-0.00018(x+32)^{2}+1.12$
B. $y=-0.00018(x+1.12)^{2}+32$
C. $y=-0.00018(x-32)^{2}+1.12$
D. $y=-0.00018(x-1.12)^{2}+32$

Correct answer: C LEVEL 3


1. The scatterplot to the left shows the number of smartphone solds, $N$, in millions, at a certain company from 2008 to 2012, where $t$ represents years since 2008. Which of the following best models the relationship between $N$ and $t$ ?
A. $N=15(0.56)^{t}$
B. $N=15(2.25)^{t}$
C. $N=11.68(1.82)^{t}$
D. $N=11.68(9.1)^{t}$

Correct answer: C LEVEL 4

2. The scatter plot at left shows the world population between the years 1950 and 2013. A function that models the data shown is:
$f(x)=0.07 x+2.34$
where $x$ represents the number of years since 1950 , and $f(x)$ represents the world population in billions of people. According to this model, what was the approximate world population in the year 1981?
A. 5.2 billion people
B. 2.34 billion people
C. $1,252.29$ billion people
D. 8.64 billion people

Correct answer: D LEVEL 4

3. The scatterplot to the left shows the percent, $P$, of Americans that reported accessing the Internet at home via dial-up Internet service. If $t$ represents the years since 2005, which of the following exponential equations best models the trend in the percent of dial-up users from2005 to 2012 ?
A. $P=30(0.7)^{t}$
B. $P=30 t(1.5)^{t}$
C. $P=-30(0.7)^{t}$
D. $P=-30(1.5)^{t}$

Correct answer: A LEVEL 4

4. The scatter plot drawn at left depicts the change in prime lending rates (interest rates) of United States (U.S.) major banks from 2004 to 2009. Which of the following functions best describes the relationship shown?
A. $y=4.02(1.25)^{x}$
B. $y=-4.02(1.25)^{x}$
C. $y=-0.65 x^{2}+3.74 x+3.17$
D. $y=0.65 x^{2}+3.74 x+3.17$

Correct answer: C LEVEL 4

5. The scatter plot drawn at left depicts the change in prime lending rates (interest rates) of United States (U.S.) major banks from 2004 to 2009. Which of the following functions best describes the relationship shown?
A. $y=-0.65 x^{2}-3.74 x+3.17$
B. $y=0.65 x^{2}-3.74 x+3.17$
C. $y=-0.65 x^{2}+3.74 x+3.17$
D. $y=0.65 x^{2}+3.74 x+3.17$

Correct answer: C LEVEL 4

6. The scatter plot at left shows the population of St. Louis, Missouri from 1950 to 2010. Based on the line of best fit to the data shown, which of the following values is closest to the average yearly change in the population of St. Louis, Missouri?
A. -9.3 thousand
B. -93.3 thousand
C. -0.11 thousand
D. -0.93 thousand

Correct answer: A LEVEL 4

7. The scatterplot to the left shows the number of teams, $t$, that play in round $r$ of a basketball tournament. For integer values of $r$, where $1 \leq r \leq 6$, which of the following equations best models the data?
A. $t=96-32 r$
B. $t=64-16 r$
C. $t=128(0.5)^{r}$
D. $t=128(2)^{r}$

Correct answer: C LEVEL 4

8. A travel agent included the scatterplot to the left in an informational brochure on Hawaii's Big Island. A best fit curve is shown on the graph, where $r$ represents the Big Island's average rainfall, in inches (in), and $m$ represents the month of the year, with $m=1$ corresponding to January, $m=2$ corresponding to February, and so on. Which of the following best approximates the difference in what the model predicts for April's average rainfall and what the statistics shows for April's average rainfall? (Note: April is the 4th month of the year.)
A. 0 in
B. 0.25 in
C. 0.60 in
D. 0.85 in

Correct answer: B LEVEL 4

A ball was dropped from an initial height of 55 feet ( ft ). A motion detector recorded the maximum height, $h$, in feet, of the ball after the $n$th bounce. The results are shown in the scatterplot below.

9. Which of the following statements best describes the situation.
A. The maximum height of the ball decreases by 0.3 ft after each bounce.
B. The maximum height of the ball decreases by 0.5 ft after each bounce.
C. The maximum height of the ball decreases by $1 \%$ after each bounce.
D. The maximum height of the ball decreases by $12 \%$ after each bounce.

Correct answer: D LEVEL 4

After drinking a can of soda that contained 58 milligrams (mg) of caffeine, an experiment was conducted in which the amount of caffeine remaining in the body was measured each hour for one day. The data is displayed in the scatterplot below.

10. If $C$ is the amount of caffeine, in mg, remaining in the body $t$ hours after the soda is consumed, which of the following is the best model for the relationship between $t$ and $C$ ?
A. $C=58-5 t$
B. $C=58-9 t$
C. $C=58(0.84)^{t}$
D. $C=58(1.88)^{t}$

Correct answer: C LEVEL 4

11. The scatter plot at left shows the temperature in degrees Celsius at different depths in meters at a location in the Pacific Ocean. A function that models the data shown is:
$f(x)=-0.12 x+24.91$
where x represents the water depth in meters, and f represents the water temperature in degrees Celsius. According to this model, at what depth will the temperature be -20 degrees Celsius?
A. 27.31 meters
B. 24.91 meters
C. 374.25 meters
D. 210 meters

Correct answer: C LEVEL 4

12. The saturation temperature for water in air is called the dew point. The scatter plot drawn at left shows the amount of water vapor, $y$, that will saturate 1 cubic meter of air at sea level for different temperatures in degrees Celsius, x. A function that models the data shown is:

$$
\mathrm{y}=4.19(1.07)^{x}
$$

What does the value 4.19 in the model tell us about the amount of water vapor that will saturate 1 cubic meter of air at sea level?
A. It will take approximately 4.19 grams of water vapor to saturate the air when the air temperature is 0 degrees Celsius.
B. It will take exactly 4.19 grams of water vapor to saturate the air when the air temperature is 0 degrees Celsius.
C. As the air temperature increases by 1 degree Celsius, the grams of water vapor needed to saturate it increases by a rate of $4.19 \%$.
D. As the air temperature increases by 1 degree Celsius, the grams of water vapor needed to saturate it decreases by a rate of $4.19 \%$.

Correct answer: A LEVEL 4

13. The scatterplot to the left shows information on organic food sales in United States (US) from 2005 to 2012, where $x$ represents years since 2005 and $y$ represents total sales, in billions of dollars, of organic food in the US. Which of the following equations best models the relationship between the number of years since 2007 and the total sales of organic food?
A. $y=15.1+0.42 x$
B. $y=15.1+2.4 x$
C. $y=0.42+15.1 x$
D. $y=2.4+15.1 x$

Correct answer: B LEVEL 4

14. The scatterplot to the left shows the costs to run a 30 second (sec) advertisement during a major sporting event from 1970 to 2010, where $\mathrm{x} x$ is years since 1970 and $\mathrm{c} c$ is the cost, in thousands of dollars. An exponential function that models the data is shown above. Based on the model, which of the following is a true statement?
A. The cost to run a 30 sec advertisement during this sporting event in 1970 was about $\$ 1.1$ million.
B. The cost to run a 30 sec advertisement during this sporting event in 2010 was about $\$ 1.1$ million.
C. Between 1970 and 2010, the cost to run a 30 sec advertisement during this sporting event increased by about $\$ 110,000$ each year.
D. Between 1970 and 2010, the cost to run a 30 sec advertisement during this sporting event increased by about $10 \%$ each year.

Correct answer: D LEVEL 4

15. The scatterplot to the left shows the population of Florida, $P$, in millions, from 1900 to 2010, where $t$ represents years since 1900 . Which of the following exponential equations best models the population of Florida from 1900 to 2010 ?
A. $P=0.710(0.53)^{t}$
B. $P=0.710(0.965)^{t}$
C. $P=0.53(1.035)^{t}$
D. $P=0.53(1.410)^{t}$

Correct answer: C LEVEL 4

16. The owners of the teams in the National Football League (NFL) have developed a trade value chart, which assigns a numerical value to recently drafted players. Draftees with the highest numerical value are considered to be most valuable on the trading market. For example, the number 1 draft pick is worth 3,000 draft points and could be traded for picks 2 (worth 2,600 points) and 50 (worth 400 points).

The scatter plot drawn at left depicts the trade value of draftees based on when they are selected in the draft. Which of the following functions best describes the relationship shown?
A. $\mathrm{f}(\mathrm{x})=0.96(2900.65)^{x}$
B. $\mathrm{f}(\mathrm{x})=2900.65(0.96)^{x}$
C. $\mathrm{f}(\mathrm{x})=2900.65(9.6)^{x}$
D. $\mathrm{f}(\mathrm{x})=960.6(0.29)^{x}$

Correct answer: B LEVEL 4

## Key features of graphs



1. The graph at left in the $s m$-plane approximates the average mileage, $\mathrm{m} m$, in miles per gallon, that Deniz's pickup truck gets when she drives at a speed of $s$ miles per hour. What is the best interpretation of the maximum point on the graph?
A. Deniz's truck gets a maximum mileage of 18 miles per gallon.
B. Deniz's truck gets a maximum mileage of 55 miles per gallon.
C. Deniz's truck can drive at a maximum speed of 18 miles per hour.
D. Deniz's truck can drive at a maximum speed of 55 miles per hour.
2. A laptop battery gains cell voltage as it charges. The battery initially charges quickly, then gradually slows as it approaches its maximum charge. Which of the following graphs in the $t v$-plane could represent the total cell voltage, $v$, in a laptop battery after $t$ minutes of charging time?
A.

B.

C.

D.


3. The graph at left in the $y I$-plane shows the interest rate percentage, $I$, one can expect for a savings account lasting $y$ years up to a maximum of 10 years.

Accounts lasting for less than 1 year are short-lived and accounts lasting for more than 5 years are long-lived. What is the significance of the $I$-intercept?
A. Short-lived accounts have the minimum interest rate of 6 percent.
B. Long-lived accounts have the minimum interest rate of 6 percent.
C. Long-lived accounts have the maximum interest rate of 11 percent.
D. The average increase in interest rates is 0.5 percent per year.

Correct answer: A LEVEL 2

4. The graph at left in the $t h$-plane shows Brayden's height, $h$, in inches above the ground, $t$ seconds after he jumps. What is the best interpretation of the $t$-intercepts of the graph?
A. Brayden jumped 0.6 feet into the air.
B. Brayden jumped 0.6 times per second.
C. Brayden remained in the air for 0.6 seconds.
D. Brayden reached the peak of his jump after 0.6 seconds.

Correct answer: C LEVEL 2

5. The graph at left in the $t h$-plane shows the function used to model the height, $h$, in feet of the top of a pool toy above the surface of the water $t$ seconds after the toy has been thrown toward the water's surface. How many seconds after the toy had been thrown did the pool toy resurface?
A. 0.1 seconds
B. 0.6 seconds
C. 1.1 seconds
D. 5 seconds

Correct answer: C LEVEL 2

6. The graph at left in the $t h$-plane represents the height, $h$, in feet above the ground, of a baseball $t$ seconds after Manon has thrown it. Which of the following is the best interpretation of the portion of the graph below the $t$-axis?
A. It represents the heights before Manon threw the ball.
B. It represents distances of the baseball below the ground.
C. It is irrelevant, because the ball will not continue descending below the ground.
D. It is irrelevant, because the heights did not follow the same pattern before Manon threw the ball.

Correct answer: C LEVEL 2

7. The graph at left in the $E H$-plane shows how mixing 3 milliliters of ethanol and water at different concentrations can release different amounts of heat, where $E$ is the percent concentration of ethanol and $H$ is the amount of heat released in joules (J). To the nearest 5 J , what is the largest amount of heat that can be released with 3 milliliters of ethanol and water?

|  | Sample answers list: <br> an integer, like 6 <br> a simplified fraction number, like $3 / 5$ <br> a simplified improper fraction, like $7 / 4$ <br> an exact decimal, like 0.75 |
| :--- | :--- |

Correct answer: 155 LEVEL 2

8. The graph at left shows the antibody production, $a$, in number of antibodies per hour $h$ hours after the introduction of a vaccine. What is the maximum number of antibodies produced per hour?

|  | Sample answers list:an integer, like 6 <br> a simplified fraction number, like $3 / 5$ <br> a simplified improper fraction, like $7 / 4$ <br> an exact decimal, like 0.75 |
| :--- | :--- |

Correct answer: 700 LEVEL 2

9. Duru drives from home to work in the morning. After several hours at work, she drives to the supermarket, buys groceries, then goes home. The graph at left in the $h d$-plane represents Duru's distance, $d$, from home in miles, $h$ hours after midnight. Which of the following is the best interpretation of the maximum on this graph?
A. Duru drives 35 miles per hour to work.
B. Duru's workplace is 35 miles from her home.
C. The supermarket is 35 miles from Duru's home.
D. Duru drives 35 miles per hour between her workplace and the supermarket.

Correct answer: B LEVEL 2

10. The plot at left in the $y D$-plane shows the depth, $D$, in meters of a volcanic lake exactly $y$ years after the date of first recording. What is the significance of the point plotted on the $D$-axis?
A. The most recently recorded depth is 175 m .
B. The depth of the lake is approximately decreasing.
C. The maximum recorded depth occurred on the first recording.
D. The volcanic lake disappears 225 years after first recording its depth.

Correct answer: C LEVEL 2


1. The graph at left in the $t M$-plane shows the results of a nuclear physicist who calculated the mass of a material produced in a fast radioactive decay as the material undergoes a slow radioactive decay at the same time. $M$ is the mass of the material in micrograms $(\mu \mathrm{g})$ and $t$ is the time in hours since the material was created. What is the significance of the point shown on the graph?
A. The point shows the mass of material at the beginning of the experiment.
B. The point shows the mass of material when the rate of increasing mass was at its greatest.
C. The point shows the amount of time elapsed since the beginning of the decay to the end of the decay.
D. The point shows the maximum mass attained and the time when this maximum was attained since the material was created.

Correct answer: D LEVEL 3

2. The graph at left in the $R I$-plane shows the current, $I$, in amperes for a circuit with a resistor having $R$ ohms of resistance. What is the significance of the value $I=4$ shown by the dotted line?
A. The current for a resistor with 0 ohms of resistance is 4amperes.
B. The current reaches a minimum when the resistor has a resistance of 4 ohms.
C. As the current becomes large, the resistance becomes approximately 4 ohms.
D. As the resistance becomes large, the current becomes approximately 4 amperes.

Correct answer: D LEVEL 3
3. An ink printer sprays droplets of ink onto a piece of paper to form text. An electric potential of $p$ millivolts ( mV ) is used to control the horizontal impact distance, $h$, measured in micrometers ( $\mu \mathrm{m}$ ) from the target where positive or negative values of $h$ represent distances to the right or left of the target respectively. Without an electric potential, 0 mV would be created and the droplet would impact $100 \mu \mathrm{~m}$ to the left of the target. An electric potential producing 200 mV allows the droplet to impact the target exactly. Which of the following graphs in the $p h$-plane could represent this situation?
A.


Potential (mV)
B.


C.

Potential (mV)

Correct answer: A LEVEL 3

4. An insurance plan pays a portion of the total cost incurred by a participant. The graph at left in the $C I$-plane shows the amount paid by insurance, $I$, for any given total cost incurred by a member, $C$, both in dollars. What is the best interpretation of the average rate of change between the points $(C, I)=(400,0) \&$ $(C, I)=(2800,1800)$ indicated on the graph?
A. If the total cost is between 400 and 2800 dollars, then insurance will pay about 75 percent of the total cost.
B. If the total cost is between 400 and 2800 dollars, then insurance will pay about 25 percent of the total cost.
C. For each dollar of the total cost above 400 and below 2800, insurance pays about 75 cents.
D. For each dollar of the total cost above 400 and below 2800 , insurance pays about 25 cents.

## Correct answer: C LEVEL 3


5. The graph at left approximates $P$, the average annual consumption of tuna per person in pounds, for a certain number of years $T$ from the beginning of the year 2000, where negative values of $T$ represent years before the beginning of 2000. At the beginning of which year did tuna consumption reach a maximum?
A. 1985
B. 2000
C. 2010
D. 2015

Correct answer: A LEVEL 3
6. Amber has an interest earning account which allows her to withdraw and deposit funds at any time. The amount, $A$, in thousands of dollars $t$ years after opening the account is graphed in the $t A$-plane. Amber performs a withdrawal 2 years after opening the account, immediately decreasing the amount. She performs a deposit 4 years after opening the account, immediately increasing the amount to equal the amount just before the withdrawal. At all other times, the amount is increasing. Which of the following graphs could represent her account?

7. The acceleration, $a$, in meters per second squared ( $\mathrm{m} / \mathrm{s} 2$ ) due to gravity is 0 at the Earth's center. It reaches a maximum of $9.8 \mathrm{~m} / \mathrm{s} 2$ at the surface of the earth approximately 4 thousand miles (mi) from the Earth's center. If $d$ represents the distance from the Earth's center in thousands of miles, which of the following graphs in the $d a$-plane could represent this relationship?
(A)

(B)

(c)

(D)


8. The graph at left in the $t D$-plane shows the relationship between $t$, the time since January 1st in days, and $D$, the distance between the Earth and the Sun at time $t$ subtracted by the mean distance between the Earth and the Sun in thousands of kilometers. What is the approximate difference between the maximum and minimum distances of the Earth from the Sun in thousands of kilometers?

|  | Sample answers list:an integer, like 6 <br> a simplified fraction number, like $3 / 5$ <br> a simplified improper fraction, like $7 / 4$ <br> an exact decimal, like 0.75 |
| :--- | :--- |

Correct answer: 50 LEVEL 3

9. The graph at left in the $s T$-plane shows the temperature, $T$, of a thermite reaction $s$ seconds after ignition. What is the average rate of increase in temperature per second between $s=0$ and $s=15$ in degrees Celsius per second?
A. 110
B. 140
C. 550
D. 1650

Correct answer: A LEVEL 3

10. The plot at left in the $t p$-plane shows the pressure, $p$, in kilopascals ( kPa ) during an ocean storm at certain times $t$ hours after noon on February 23. The storm is most intense when the pressure is at a minimum. What is the difference between the pressure at noon on February 23 and the pressure during the most intense part of the storm to the nearest kilopascal?


Correct answer: 3 LEVEL 3
Sample answers list:
an integer, like 6
a simplified fraction number, like $3 / 5$
a simplified improper fraction, like 7/4
an exact decimal, like 0.75

11. The plot at left in the $T h$-plane shows how the height, $h$, in inches (in)of the first bounce of a ball dropped from 3 feet depends on the temperature, $T$, in degrees Fahrenheit ( $\circ \mathrm{F}$ ). What is the significance of the value $h=27$ as shown by the dotted line?
A. The ball reaches a height of 80 in at a temperature of $0 \circ \mathrm{~F}$.
B. The ball reaches a height of 80 in at a temperature of $27 \circ \mathrm{~F}$.
C. The ball reaches a maximum height of 27 in across all temperatures shown.
D. The ball reaches a maximum height of 27 in approximately 80 in along its trajectory.

## Correct answer: C LEVEL 3


12. The graph at left in the ap-plane shows $p$, the atmospheric pressure of Earth in pounds per square inch (psi), for a given value of $a$, the altitude above sea level in kilometers. The Earth's atmosphere has the property that there is a fixed distance $d_{\frac{1}{2}}$ such that for any altitude $a 0$, the pressure at an altitude of $a 0+d_{\frac{1}{2}}$ is one half $\overline{2}$ the pressure at an altitude of $a 0$. What is the approximate value of $d_{\frac{1}{2}}$ ?
A. 1 KM
B. 5.6 KM
C. 15 KM
D. 25 KM

Correct answer: B LEVEL 3
13. Bibb lettuce is grown hydroponically using water and a mixture of nitrates. The mass, $\mathrm{m} m$, in grams ( g ) of a mature head of lettuce growing in a nitrate concentration, $C$, in grams per liter $(\mathrm{g} / \mathrm{L})$ is plotted at various concentrations. The mass reaches a maximum at a concentration of $15 \mathrm{~g} / \mathrm{L}$. Only once the concentration is at least $40 \mathrm{~g} / \mathrm{L}$ is the lettuce unable to grow, and therefore, has a mass of 0 gm . Which of the following plots in the Cm-plane could represent this situation?
(A)

(B)


Concentration (g/L)
(C)


Concentration ( $\mathrm{g} / \mathrm{L}$ )
(D)

Concentration ( $\mathrm{g} / \mathrm{L}$ )

Correct answer: D LEVEL 3

14. The graph at left in the ta-plane shows the acceleration, $a$, in meters per second per second ( $\mathrm{m} / \mathrm{s} 2$ ) of a dropped elastic ball $t t$ milliseconds (ms) after the ball impacts a tile surface. What is the significance of the graph at $t=15 \mathrm{~ms}$ ?
A. The elastic ball touches the ground for 30 ms .
B. The elastic ball reaches its greatest height 15 ms after impact.
C. The elastic ball experiences the greatest acceleration 15 ms after impact.
D. The elastic ball experiences the greatest acceleration 15 ms after being dropped.

## Correct answer: C LEVEL 3


15. The National Retail Federation introduced the term "Cyber Monday" in 2005 to describe a sharp rise in online revenue and traffic the first Monday after Thanksgiving. The graph at left in the $t r$-plane approximates the total revenue, $r$, in millions of dollars, from Cyber Monday sales in the year $t$ years after 2009.

What is the best interpretation of the portion of the graph to the left of the $r$-axis?
A. It refers to loss of revenue.
B. It refers to revenue in years before 2009.
C. It is irrelevant, because you cannot have negative revenue.
D. It is irrelevant, because there were no Cyber Monday sales before 2009.

Correct answer: B LEVEL 3
16. Using the doppler effect, astronomers can determine the frequency of light, $f(v)$, in terahertz ( THz ) emitted from a galaxy with a velocity in the direction toward Earth of $v$, in fractions of the speed of light $c$. It is true that galaxies with a velocity of 0 THz toward Earth emit light with a positive frequency, and frequency is never 0 THz for any velocity. Additionally, as the velocity toward Earth increases, the frequency of light emitted increases. Which of the following could represent the graph of $y=f(v)$ in the $y$-plane?
(A)

(B)

(c)

(D)


Velocity(fraction of $c$ )
Correct answer: B LEVEL 3

17. The graph at left in the $m P$-plane shows a storm cloud creating a potential difference, $P$, in megavolts (MV) between the bottom of the cloud and the surface of the Earth $m$ minutes after the start of recording by a weather balloon. The potential difference increases until a lightning strike occurs, during which the potential difference instantaneously drops to 0 V . What is the significance of the point marked?
A. The storm lasts 3.5 minutes.
B. The potential difference is 0 MV just after the lightning strike.
C. The potential difference is around 64 MV just before the lightning strike.
D. The potential difference reaches a maximum of 3.5 MV after 64 minutes.

## Correct answer: C LEVEL 3

18. A deep sea hydrophone began recording for 180 seconds as soon as it sensed a sound greater than the threshold intensity of 200 underwater decibels (dB). The sound intensity, $I$, in dB reached a maximum at 60 seconds after recording and then gradually decreased for the next 120 seconds. If $t$ is the number of seconds since the beginning of recording, which of the following graphs in the $t I$-plane could model the sound?
(A)

(B)

(C)

(D)


Correct answer: A LEVEL 3

19. The plot above in the $d G$-plane was created by a winemaker measuring the growth rate, $G$, in milligrams per day ( $\mathrm{mg} /$ day) of grapes $d$ days after budding. The winemaker plans on harvesting the grapes when the growth rate reaches 0 . How many days after the growth rate reaches a maximum does the winemaker plan on harvesting the grapes?

|  | Sample answers list: <br> an integer, like 6 <br> a simplified fraction number, like 3/5 <br> a simplified improper fraction, like $7 / 4$ <br> an exact decimal, like 0.75 |
| :--- | :--- |

Correct answer: 50 LEVEL 3

20. The terminal velocity of an object is the velocity reached after falling a large enough height such that its velocity no longer changes. The plot at left in the $h v$-plane shows the ground impact velocity, $v$, in meters per second of a ping pong ball dropped from a height of $h$ meters above the ground. What appears to be the terminal velocity of the ping pong ball to the nearest meter per second?


Sample answers list:
an integer, like 6
a simplified fraction number, like $3 / 5$
a simplified improper fraction, like 7/4
an exact decimal, like 0.75
Correct answer: 9
LEVEL 3

21. The graph at left in the $s T$-plane shows the temperature, $T$, in degrees Fahrenheit $(\circ \mathrm{F})$ of an incandescent light bulb $s$ seconds after being initially turned on from a temperature of $50 \circ \mathrm{~F}$. While on, the temperature was always increasing. Less than a minute after being turned on, the light bulb was turned off and its temperature started decreasing. By approximately how many Fahrenheit degrees did the light bulb's temperature increase while being turned on?
A. 30
B. 125
C. 225
D. 275

## Correct answer: C LEVEL 3


22. The temperature, $T$, in degrees Celsius ( ${ }^{\circ} \mathrm{C}$ ) along a circular infrared stove measured $d$ centimeters (cm) from the left edge of the circumference and going through the center of the stove is given by the graph at left. The hottest point occurs at the center of the stove. What is the diameter of the stove in centimeters?

|  | Sample answers list: <br> an integer, like 6 <br> a simplified fraction number, like 3/5 <br> a simplified improper fraction, like $7 / 4$ <br> an exact decimal, like 0.75 |
| :--- | :--- |

Correct answer: 40 LEVEL 3
23. An electromagnetic pulse is generated and its profile at a distance $D$, in micrometers ( $\mu \mathrm{m}$ ), is taken 1 picosecond later. The magnetic field, $M$, in nanotesla (nT) reaches a minimum of 4 nT at a distance of $50 \mu \mathrm{~m}$ from the source. The magnetic field reaches a maximum of 10 nT at a distance of $90 \mu \mathrm{~m}$. Which of the following graphs in the $D M$-plane could represent this situation?
(A)

(B)

(c)

(D)


Correct answer: D LEVEL 3


1. The graph at left in the $m f$-plane relates the length in meters (m) of a particular thickness of guitar string to the frequency in Hertz $(\mathrm{Hz})$ at which it will vibrate for a first harmonic note. By what factor does the frequency decrease between string lengths of 0.5 m and 0.6 m ?
A. 0.16
B. 0.5
C. 0.6
D. 0.75

Correct answer: D LEVEL 4
2. Based on the bone mass to body mass ratio of modern reptiles, paleontologists can use the fossils of the Tyrannosaurus Rex dinosaur to predict its rate of growth, $r$, in kilograms per year $(\mathrm{kg} / \mathrm{yr})$ at a particular age, $a$, in years. The rate of growth has a minimum of $50 \mathrm{~kg} / \mathrm{yr}$ when the dinosaur's age is less than 1 year and greater than 29 years. Additionally, the rate of growth reaches a maximum of $600 \mathrm{~kg} / \mathrm{yr}$ when $a$ is 16 years. Which of the following graphs in the ar-plane could show this relationship?
(A)

(B)


(D)

3. A retail store is purchasing $n$ coats from a specialty coat designer. The cost per coat, $C$, in dollars reaches a minimum when 125 coats are purchased and reaches a maximum of $\$ 300$ when 1 coat is purchased. Which of the following graphs in the $n C$-plane could represent the cost per coat when purchasing $n$ coats?
(A)

(B)

(c)

(D)


Correct answer: A LEVEL 4

4. The graph in the $x C$-plane at left shows the long run average cost curve for a company producing appliances. The function $C$ gives the average production cost per appliance when the total output is $x x$ appliances per day. Approximately how many appliances should the company produce per day to minimize average production cost?
A. 28 appliances
B. 50 appliances
C. 600 appliances
D. 1200 appliances

Correct answer: C LEVEL 4
5. A computer clock changes its voltage, $v$, in volts (V) over a time, $t$, in nanoseconds (ns) in order to control the execution of instructions. The clock starts with a voltage of 0 V , then increases to 0.1 V and stays at 0.1 V for exactly 10 ns , and finally decreases to 0 V . Which of the following graphs in the $t v$-plane could represent this situation?
(A)

(B)

(c)

(D)


Correct answer: A LEVEL 4
6. Ebru accelerates her car from a stoplight, drives at a constant speed for a few blocks, then slows to a stop at another stoplight. Which of the following graphs in the $t d$-plane could best represent the relationship between the distance, $d$, and driving time, $t$, of Ebru's car?
(A)

(B)

(c)

(D)

7. A team of oceanographers are measuring the salinity of the water in the southern Indian Ocean at different depths. They plot the salinity $s$ in grams of salt per kilogram of ocean water $(\mathrm{g} / \mathrm{kg})$ versus the depth $D$ in kilometers. They find that the salinity reaches a minimum at a depth of 0.75 kilometers. They also find that the maximum salinity of $35.5 \mathrm{~g} / \mathrm{kg}$ occurs at the surface of the ocean. Which of the following plots in the $s D$-plane best represents their findings?
(A)

(B)


D
(c)



Correct answer: D LEVEL 4
8. For the concession stand, students purchase a number of pizzas, then sell them by the slice. If the students set their price per slice too low, they lose money on each slice. If they set it too high, fewer people will buy the pizza and the students will also lose money. If they set their price at $\$ 0.70$ a slice or $\$ 2.50$ a slice, they break even. To break even means that the costs equal the money earned. Which graph in the $x p$-plane could best represent the total profit, $p$, in dollars, from pizza sales when the students charge $\mathrm{x} x$ dollars per slice?
(A)

(B)

(c)



Correct answer: D LEVEL 4
9. Americium- 241 is a radioactive element commonly found in smoke detectors. A sample that begins with 1 microgram of Americium-241 has an average rate of change of $-1 / 864$ micrograms ( $\mu \mathrm{g}$ ) per year for the first 432 years, and an average rate of change of $-1 / 1728 \mu \mathrm{~g}$ per year for the next 432 years. Which of the following graphs could best represent the mass $\mathrm{m} m$, in $\mu \mathrm{g}$, of the Americium-241 remaining in a sample after $t$ years?
(A)

(B)

(c)

(D)


Correct answer: C LEVEL 4
10. A foreign species of insect has invaded a small island and begins to consume the island's mustard plants over a time, $T$, in months. The area inhabited by mustard plants, $A$, in acres (ac) immediately after the insect's introduction is 20 ac , and after 6 months the mustard plants disappear from the island. Which of the following graphs in the $T A$-plane could represent this situation?
(A)



(D)


Correct answer: A LEVEL 4
11. A chemical undergoes an autocatalytic reaction. The concentration of the chemical, $C$, in grams per liter $(\mathrm{g} / \mathrm{L})$ changes fastest when $s$, the number of seconds since the start of the reaction, is 10 seconds. Thereafter, the concentration approaches $8 \mathrm{~g} / \mathrm{L}$. Which of the following graphs in the $s C$-plane could model the chemical reaction?
(A)

(B)

(c)

(D)


Correct answer: A LEVEL 4
12. The average monthly solar radiation $r$, in kilowatt hours per square meter $\left(\frac{k H}{m^{2}}\right)$, absorbed by a solar panel at $0 \circ$ inclination in Monterrey Mexico reaches a peak during the summer solstice, which occurs approximately June 21st. Which of the following graphs could show the relationship between the number of months, $m$, after January 21 st and the kilowatt hours, $r$, of solar radiation absorbed by the panel?
(A)

(B)


(D)


Correct answer: B LEVEL 4

13. In a Ferris wheel, pictured at left, a passenger car travels in a circular path as the ride revolves. The graph above in the $t h$-plane shows the height, $h$, above the ground, in meters, of a passenger car on a Ferris wheel, $t$ minutes after the ride reaches full speed. At full speed, how many revolutions per minute does the passenger car of the Ferris wheel make?
A. 6 revolutions
B. 7 revolutions
C. 9 revolutions
D. 10 revolutions

Correct answer: A LEVEL 4

14. The graph at left in the $d w$-plane relates the number of decibels $\mathrm{d}(\mathrm{dB})$ of a sound to the sound intensity, $w$, in watts per square centimeter. By what factor does the sound intensity increase between 6 and 7 dB ?
A. 0.8
B. 1.25
C. $\frac{1 \times 10^{16}}{3}$
D. $\frac{2 \times 10^{16}}{7}$

Correct answer: B LEVEL 4
15. A loan is paid back with increasing payments. The balance of the loan upon purchase is equal to $\$ 6,000$. The balance reaches a maximum 2 years after purchase and 5 years after purchase it reaches $\$ 0$. If $L$ is the balance of the loan in thousands of dollars and $t$ is the time since the purchase, which of the following graphs in the $t L$-plane represents this payment plan?
(A)

(B)

©

(D)


Correct answer: B LEVEL 4
16. An indifference curve plots the amounts $x$ of product $X$ and the amount $y$ of product $Y$ such that the value to a consumer of the total amount of products $X$ and $Y$ for any point along the curve is constant. It has the property that $y$ decreases as $x$ increases. For one consumer, good $X$ is flour, good $Y$ is sugar, $x$ and $y$ are in pounds, and 5 pounds of flour alone have the same value as 3 pounds of sugar alone. Which of the following could represent the indifference curve in the $x y$-plane for this consumer?
(A)

(B)

(c)

(D)


Correct answer: B LEVEL 4
17. The graph at left in the ta-plane approximates the total amount, $a$, in dollars, that a particular video hosting company charges a customer who uses $t$ terabytes of bandwidth. What is the best interpretation of the average rate of change between 10 and 35 terabytes?

A. The company charges about $\$ 91$ per terabyte up to the tenth terabyte.
B. The company charges about $\$ 110$ per terabyte up to the tenth terabyte.
C. The company charges about $\$ 91$ per terabyte after the tenth terabyte but before the thirty-fifth.
D. The company charges about $\$ 110$ per terabyte after the tenth terabyte but before the thirty-fifth.

## Correct answer: C LEVEL 4


18. The graph at left in the $s C$-plane shows the hourly $\operatorname{cost} C$ in dollars to a small clothing factory producing $s$ shirts in one hour. Which of the following is correct regarding the average cost per shirt when producing $s$ shirts in one hour?
A. The average cost always increases as the number of shirts produced in one hour increases.
B. The average cost always decreases as the number of shirts produced in one hour increases.
C. The average cost reaches a maximum when the number of shirts produced in one hour is 100 .
D. The average cost reaches a minimum of 0.25 dollars per shirt per hour.

Correct answer: B LEVEL 4

19. A surveyor is tracking the elevation of a trail at fixed increments of 500 meters. The plot at left in the $D E$-plane shows the elevation, $E$, in meters (m) above the starting point versus the distance, $D$, along the trail from the start in kilometers $(\mathrm{km})$. What is the average rate of change in elevation with respect to distance along the trail in $\mathrm{m} / \mathrm{km}$ between the starting point and the point of highest elevation?

|  | Sample answers list: |
| :--- | :--- |
|  | an integer, like 6 <br> a simplified fraction number, like $3 / 5$ <br> a simplified improper fraction, like $7 / 4$ <br> an exact decimal, like 0.75 |

Correct answer: 20 LEVEL 4

20. The graph at left in the $t h$-plane shows the height above ground, $h$, in meters $(\mathrm{m})$ of a projectile $t$ seconds (s) after it has been fired upward. To the nearest 5 meters per second, what is the absolute value of the average rate of change of height in terms of time between the time the projectile was at its highest point and the time the projectile hit the ground?

|  | Sample answers list: |
| :--- | :--- |
|  | an integer, like 6 <br> a simplified fraction number, like $3 / 5$ <br> a simplified improper fraction, like $7 / 4$ <br> an exact decimal, like 0.75 |

Correct answer: 20 LEVEL 4
21. The rectangular floor of a playpen has a perimeter of 24 feet. Which of the following graphs in the $w A$-plane could represent the relationship between the width, $w$, in feet, and the floor area, $A$, in square feet, of the playpen?
(A)

(B)


(D)


Correct answer: B LEVEL 4
22. A call option gives the purchaser the option to buy a stock in the future at a particular price known as the strike price. The dollar profit, $P$, of a call option is a constant negative value when the future dollar stock price, $S$, is less than the strike price. When the stock price is above the strike price, $P$ increases from its constant negative value at the rate of $\$ 1$ per dollar of $S$. Which of the following graphs in the $S P$-plane could be the graph of a call option with a strike price of $\$ 15$ ?


Correct answer: D LEVEL 4

## Linear and exponential growth

## 1.

Laxman recently started a restaurant 32 weeks ago. The table at left shows the number of customers, $\boldsymbol{C}$, during the $w^{\text {th }}$ week. Which of the following correctly explains the growth of $\boldsymbol{C}$ with respect to $w$ ?

| $w$ | $C$ |
| ---: | ---: |
| 1 | 30 |
| 2 | 60 |
| 4 | 120 |
| 8 | 240 |
| 16 | 480 |
| 32 | 960 |

A. The number of customers per week grew linearly because the number of customers per week increased by approximately 30 every week.
B. The number of customers per week grew linearly because the number of customers per week increased by approximately 100 every week.
C. The number of customers per week grew exponentially because the number of customers per week increased by approximately 30 every week.
D. The number of customers per week grew exponentially because the number of customers per week increased by approximately 100 every week.

## Correct answer: A

## Difficulty level: 2

## 2.

12 grams ( g ) of a chemical are added to a metal. The amount, A, in grams of the chemical remaining during a reaction with a metal plate, decrease by 0.5 g every second. If instead the plate were dissolved, the amount, $\hat{A}$, in grams of chemical remaining, would decrease by a factor of 2 every four seconds. How much greater is A than $\hat{A}$ in grams after 12 seconds?


## Correct answer: 4.5

## Difficulty level: 2

3. 

An old computer program which computer the $n^{\text {th }}$ Fibonacci number takes 0.05 microseconds $(\mu s)$ to compute the $1^{\text {st }}$ number and it takes twice as long to compute each successive number. A computer engineer designs a new program which takes $0.8 \mu s$ to compute the $1^{\text {st }}$ Fibonacci number, and it takes an additional $0.6 \mu s$ more to compute each successive number. How much longer in microseconds does it take the old program to compute the $8^{\text {th }}$ Fibonacci number compared to the new program?
A. 0.8
B. 1.4
C. 7.2
D. 7.8

## Correct answer: B Difficulty level: 2

4. $s=320+115 t$

The equation above approximates the relationship wildlife veterinarians found between the amount, $\boldsymbol{t}$, in micrograms per deciliter $\left(\frac{\mu g}{d \boldsymbol{l}}\right.$ ), of course( a stress hormone) in a wild harbor seal's tear to the amount, $s$, in $\frac{\mu g}{d l}$, of cortisol in the seal's serum. Which of the following statements best describes the relationship between the amount of cortisol in a seal's tears and serum (between $t$ and $\boldsymbol{s}$ )?
A. It is linear because there is an $11.5 \frac{\mu g}{d l}$ increase in $s$ for every $0.1 \frac{\mu g}{d l}$ increase in $t$.
B. It is linear because there is a $32 \frac{\mu g}{d l}$ increase in $s$ for every $0.1 \frac{\mu g}{d l}$ increase in $t$.
C. It is exponential because there is a $15 \%$ increase in $\boldsymbol{s}$ for every $0.01 \frac{\mu g}{d l}$ increase in $\boldsymbol{t}$.
D. It is exponential because there is a $220 \%$ increase in $s$ for every $0.01 \frac{\mu g}{d l}$ increase in $t$.

## Correct answer: A Difficulty level: 2

5. $r=35.7+1.37 t$

The equation above relates the urbanization rate $r$, as a percent, in a particular country to the number of years $t$ since 2000. Which of the following statements best describes the relationship between the year since 2000 and the urbanization rate?
A. It is linear because the urbanization rate increases by 35.7 each year.
B. It is linear because the urbanization rate increases by 1.37 each year.
C. It is exponential because the urbanization rate increases by $35.7 \%$ each year.
D. It is exponential because the urbanization rate increases by a factor of 35.7 each year.

Correct answer: B Difficulty level: 2
6.

The cell cycle is the process by which a single cell replicates itself. A microbiologist debates whether cell growth during the cell cycle is linear or exponential. The table at left gives the length, in micrometers, of an S. pombe(yeast) cell at different times after the cell cycle begins. Which of the following best describes the relationship between time and length of this cell?

| Minutes | Length (micrometers) |
| :---: | ---: |
| 10 | 14.5 |
| 20 | 27.9 |
| 30 | 53.8 |
| 40 | 103.7 |
| 50 | 200.1 |
| 60 | 385.8 |
| 70 | 744.0 |
| 80 | $1,434.9$ |
|  |  |

A. It is linear because the length increases by the same factor every 10 minutes.
B. It is linear because the length increases by the same number every 10 minutes.
C. It is exponential because the length increases by the same factor every 10 minutes.
D. It is exponential because the length increases by the same number every 10 minutes.

## Correct answer: C Difficulty level: 2

7. $v(t)=0.41 \cdot 0.8^{\frac{2 t}{5}}$

A researcher studied the ability of a gelatin sample to retain an electrical charge. The function above approximates the voltage, in volts, of the sample $t$ minutes after it has been charged. Which of the following statements best describes the relationship between the voltage and the number of minutes?
A. It is linear because the voltage increases by 0.41 volts every 2.5 minutes.
B. It is linear because the voltage decreases by 0.8 volts every 0.4 minutes.
C. It is exponential because the voltage decreases by $20 \%$ every 2.5 minutes.
D. It is exponential because the voltage increases by $20 \%$ every 0.4 minutes.

## Correct answer: C <br> Difficulty level: 2

8. 

| Page size (in kilobytes) | Loading time (in milliseconds) |
| :---: | :---: |
| 25 | 8 |
| 50 | 12 |
| 75 | 16 |
| 100 | 20 |
| 125 | 24 |
| 150 | 28 |
| 175 | 32 |
| 200 | 36 |
| 225 | 40 |

Web developers need to know how long a page will take to load. The table at left gives loading times according to page size when using a particular interface. Which of the following statements best describes the relationship between the page size and loading time?
A. It is linear because the loading time increases by the same factor for each increases by 25 kilobytes in the page size.
B. It is linear because the loading time increases by the same amount for each increases by 25 kilobytes in the page size.
C. It is exponential because the loading time increases by the same factor for each increases by 25 kilobytes in the page size.
D. It is exponential because the loading time increases by the same amount for each increases by 25 kilobytes in the page size.

## Correct answer: B <br> Difficulty level: 2

9. 

Oxygen reduction potential (ORP) is a common measurement for water quality. The table at left relates the ORP, in microvolts $(\boldsymbol{\mu} \boldsymbol{V})$, to the number of seconds required to purify $\mathbf{9 9 . 9 \%}$ of E. coli bacteria from a liquid. Which of the following best describes the relationship between the ORP and the purification time?

| ORP $(\mu \mathrm{V})$ | Purification time (seconds) |
| ---: | ---: |
| 620 | 61 |
| 640 | 38 |
| 660 | 24 |
| 680 | 15 |
| 700 | 9 |
| 720 | 6 |
| 740 | 4 |

A. It is approximately linear because for every $20 \boldsymbol{\mu} \boldsymbol{V}$ increase in ORP, the purification time decreases by a fixed amount.
B. It is approximately linear because for every $20 \mu \boldsymbol{V}$ increase in ORP, the purification time decreases by a common amount.
C. It is approximately exponential because for every $20 \boldsymbol{\mu} \boldsymbol{V}$ increase in ORP, the purification time decreases by a fixed amount.
D. It is approximately exponential because for every $20 \mu V$ increase in ORP, the purification time decreases by a fcommon amount.

## Correct answer: D

## Difficulty level: 2

10. $E(t)=0.63 \cdot 0.98^{t}$

The function above relates the elevation $\boldsymbol{E}$, in pulses per second, of a particular neuron above its unstimulated neural response, $\boldsymbol{t}$ milliseconds after it reaches its peak response. Which of the
following best describes the relationship between the time after the peak response and the elevation of the neural response?
A. It is linear because every millisecond the elevation declines by a certain factor.
B. It is linear because every millisecond the elevation declines by a certain number of pulses per second.
C. It is exponential because every millisecond the elevation declines by a certain factor.
D. It is exponential because every millisecond the elevation declines by a certain number of pulses per second.
Correct answer: C Difficulty level: 2
11.

Eitan posted a video on the internet which only received approximately $\mathbf{1 0 0}$ views per day for the first $\mathbf{3 6 5}$ days after it was posted. However, on the $\mathbf{3 6 5}{ }^{\text {th }}$ day, Eitan's video began to receive a greater following: the total number of views grew at a rate of $\mathbf{2 5 \%}$ per day until the $\mathbf{3 7 2}^{\text {nd }}$ day. If Eitan's video had zero views when he first posted it on the internet, approximately how many more views did Eitan's video receive between the $\mathbf{3 6 5}^{\text {th }}$ to the $\mathbf{3 7 2}{ }^{\text {nd }}$ day compared to the first $\mathbf{3 6 5}$ days after his video was posted?
A. 36,500
B. 101,000
C. 138,000
D. 174,000

## Correct answer: B

Difficulty level: 3
12. $P=A\left(\mathbf{1}-\frac{d}{100}\right)^{t}$

The present value, $\boldsymbol{P}$, in dollars of a cash flow $\boldsymbol{t}$ years from now is shown by the equation above where $\boldsymbol{A}$ is the future amount of the cash flow in dollars and $\boldsymbol{d}$ is the discount rate expressed as a percent. In such models, $\boldsymbol{A}$ and $\boldsymbol{d}$ are both positive constants. Which of the following correctly explains the relationship between $\boldsymbol{P}$ and $\boldsymbol{t}$ ?
A. This is a linear relation because $\mathbf{1}-\frac{\boldsymbol{d}}{\mathbf{1 0 0}}$ is a constant
B. This is a linear relationship because $\boldsymbol{A}$ acts as the constant of proportionality.
C. This is an exponential relationship because $\boldsymbol{P}$ is decreasing as $\boldsymbol{t}$ increases.
D. This is an exponential relationship because $t$ is in the exponent of a constant.

Correct answer: D Difficulty level: 3
13. $\frac{P}{Y}=1.50$

The price of a good, $\boldsymbol{P}$, in dollars between the years 2005 and 2010 can be approximated using the equation above where $\boldsymbol{Y}$ is the number of years since the beginning of $\mathbf{2 0 0 0}$. Which of the following correctly describes the growth of $\boldsymbol{P}$ with respect to $\boldsymbol{Y}$ ?
A. $\boldsymbol{P}$ increases linearly by $\mathbf{1 . 5 0}$ each year.
B. $\boldsymbol{P}$ increases exponentially by $\mathbf{1 . 5 0}$ each year.
C. $\boldsymbol{P}$ increases linearly by $\mathbf{5 0}$ percent each year.
D. $\boldsymbol{P}$ increases exponentially by $\mathbf{5 0}$ percent each year.

Correct answer: A Difficulty level: 3
14.

On mobile devices, global voice traffic has been growing by approximately $\mathbf{2}$ petabytes $(\mathbf{P B})$ per month, while global data traffic has been growing by approximately $\mathbf{7 \%}$ per month. One month in 2007, both traffic volumes equaled $\mathbf{1 1 0} \mathbf{~ P B}$ per month. What was the total expected traffic data and voice) $\mathbf{4}$ months later? Round to the nearest PB.


## Correct answer: 262

## Difficulty level: 3

15. 

A bank is offering a simple interest rate of $\mathbf{5 \%}$-- that is, the bank will pay a fixed $\mathbf{5 \%}$ of an initial investment as interest each year. By contrast, a stockbroker is offering a $\mathbf{4 \%}$ interest rate compounded annually: $\mathbf{4 \%}$ of the total value of the investment at the end of the year. If $\mathbf{\$ 1 0 0 0}$ is invested in the bank and $\$ \mathbf{1 0 0 0}$ is invested with the stockbroker, after $\mathbf{4}$ years, what will be the total values of the two investments? Round to the nearest dollar.


Correct answer: 2370
Difficulty level: 3
16. $P=a \cdot(1+b)^{k t}$

A genetic mutation which adapts a fruit to a higher humidity spreads among a species of fruiting plants. The population present with the mutation, $\boldsymbol{P}$, can be approximated using the equation above where $\boldsymbol{t}$ is the time in years since the introduction of the mutation, $\boldsymbol{a}$ is a positive constant equal to the initial mutation population, $\boldsymbol{b}$ is a positive constant, and $\boldsymbol{k}$ is a constant. Which of the following correctly explains why $\boldsymbol{P}$ would be exponentially or linearly increasing?
A. $\boldsymbol{P}$ is linearly increasing if $k>0$.
B. $\boldsymbol{P}$ is linearly increasing if $a>1$.
C. $\boldsymbol{P}$ is exponentially increasing if $k>0$.
D. $\boldsymbol{P}$ is exponentially increasing if $a>1$.

## Correct answer: C

Difficulty level: 4
17.

A statistician modeled the average private law school tuition in two ways. According to both models, the tuition in 2011 was about $\mathbf{\$ 4 0 , 0 0 0}$. In one model, the tuition increased by $\mathbf{\$ 1 7 5 0}$ per
year. In the other, the tuition increased by $\mathbf{5 \%}$ per year. What would be the difference between these models in the year 2013?


Correct answer: 600

## Difficulty level: 4

18. 

An accountant is modeling the annual tax expenditures, $\mathbf{E}$, in thousands of dollars t years after January $\mathbf{1}^{\text {st }}, \mathbf{2 0 0 0}$ for a small business using two different models. Both of the accountant's models have tax expenditures of $\mathbf{\$ 5 0 0 0}$ on January $\mathbf{1}^{\text {st }} \mathbf{, 2 0 0 0}$. Model 1 has tax expenditures which increase by $\$ \mathbf{4 0 0 0}$ each year. Model $\mathbf{2}$ has tax expenditures which increase by a factor of a every $\mathbf{5}$ years. If the models have the same value on January $\mathbf{1}^{\text {st }}, \mathbf{2 0 1 0}$, what is the value of a?


## Correct answer: 3

## Difficulty level: 4

19. 

For the last decade, the number of insured children who had dental cleanings has been growing by $\mathbf{5 \%}$ per year or by about $\mathbf{6 8}$ children per year, depending on how the growth is modeled. This year, 1760 insured children have dental cleanings. To the nearest child, what is the difference between the numbers whom the models predict will have dental cleanings $\mathbf{3}$ years from now?


## Correct answer: 73

## Difficulty level: 4

20. 

From 1945 to 2008, one country's per capita gross domestic product (GDPPC) increased about $\mathbf{6 \%}$ per year, ending at $\mathbf{\$ 1 9 , 6 0 0}$. For the next few years, the growth slowed to an increase of about $\mathbf{\$ 1 3 0 0}$ per year. To the nearest dollar, how much less did the GDPPC grow during the next $\mathbf{6}$ years than it would have if it had maintained its earlier growth rate?
$\square$

## Correct answer: 403

## Difficulty level: 4

21. 

An astronomer observes the velocity of a galaxy at a distance of $\mathbf{1 0 0}$ megaparsecs ( $\mathbf{M p c}$ ) to calculate its distance two billion years from now using two different models. In the first model, the distance from the galaxy to Earth increases by $\mathbf{9 M p c}$ every billion years. In the second model, the distance from the galaxy to Earth increases by $\mathbf{1 0}$ percent every billion years. Two billion years from now, how much further would the galaxy be in the second model compared to the first model
in megaparsecs?


Correct answer: 3
Difficulty level: 4
22.

In one community college, the cost per credit hour for in-state students has been increasing by $\mathbf{\$ 3}$ a year. In another community college, it has been increasing by $\mathbf{9 \%}$ per year. This year, the cost is $\$ 65$ at both colleges. To the nearest dollar, what was the positive difference in costs $\mathbf{2}$ years ago?
$\square$

## Correct answer: 4

## Difficulty level: 4

23. 

A pilot is testing the change in external pressure during ascent from a pressure of $\mathbf{1}$ atmosphere $(\boldsymbol{a t m})$. If the plane ascends at a constant rate, the pressure drops by $\mathbf{3 0}$ percent every ten minutes. If the plane ascends at a decreasing rate, the pressure drops by $\mathbf{0 . 1 a t m}$ every ten minutes. After thirty minutes, what is the pressure at a constant rate of ascent minus the pressure at a decreasing rate of ascent in atmospheres?
A. -0.629
B. -0.6
C. -0.386
D. -0.357

## Correct answer: D Difficulty level: 4

24. 

A single processor takes 20 milliseconds (ms) to prepare data entries and $\mathbf{0 . 1} \mathbf{n} \mathbf{m s}$ to copy the entries, where $\boldsymbol{n}$ is the number of entries. A multiprocessor takes $\mathbf{7 0 m s}$ to prepare and copy one data entry, and whenever the number of entries is doubled the amount of time to prepare and copy them increases by $\mathbf{5 m s}$. Given $\mathbf{1 2 0} \mathbf{m s}$ to prepare and copy data entries, which processor type can prepare and copy more entries and how many more entries can it prepare and copy?
A. The single processor can prepare and copy $\mathbf{1 7 6}$ more entries.
B. The single processor can prepare and copy $\mathbf{9 8 9}$ more entries.
C. The multiprocessor can prepare and copy 24 more entries.
D. The multiprocessor can prepare and copy $\mathbf{1 , 0 1 2}$ more entries.

## Correct answer: C Difficulty level: 4

25. 

A surveyor discovers that the total combined length of all roads, in miles (mi), of a particular city was 500 at the beginning of 1950 and increased by $\mathbf{1 2 5 m i}$ every ten years. Additionally, the number of cars driven in the city was $\mathbf{5 0 , 0 0 0}$ at the beginning of $\mathbf{1 9 5 0}$ and increased by $\mathbf{2 0}$ percent
every ten years. What was the difference between the number cars driven in the city per mile of city road at the beginning of $\mathbf{1 9 5 0}$ and at the beginning of $\mathbf{1 9 9 0}$ ?
A. 3.68
B. 10
C. 107.36
D. 103.68

Correct answer: A Difficulty level: 4
26.

The number of data objects stored in a company's "cloud" increased $190 \%$ per year for the first 5 years, when it reached 762 billion objects. During the next year, the company reported that 1 billion objects were being added daily. If the growth rate had not changed, how many more objects would there have been at the end of the year? Use 365 days per year.
A. 1.1 trillion objects
B. 2.2 trillion objects
C. 320 trillion objects
D. 397 trillion objects

## Correct answer: A

## Difficulty level: 3

27. 

The table at left shows the percent compression of a coil spring in a mattress, which is measured when different amounts of force are applied. Which of the following best describes the relationship between the percent compression and the force?

| Force (kilonewtons) | Percent compression |
| :---: | :---: |
| 15 | $3 \%$ |
| 30 | $6 \%$ |
| 45 | $9 \%$ |
| 60 | $11 \%$ |
| 75 | $13 \%$ |
| 90 | $15 \%$ |
| 105 | $18 \%$ |
| 120 | $20 \%$ |
|  |  |

A. It is approximately linear because the percent compression nearly doubles for every increase of 15 kilonewtons of force.
B. It is approximately linear because the percent compression grows by about 2.5 for every increase of 15 kilonewtons of force.
C. It is approximately exponential because the percent compression nearly doubles for every increase of 15 kilonewtons of force.
D. It is approximately exponential because the percent compression grows by about 2.5 for every
increase of 15 kilonewtons of force.

## Correct answer: B

Difficulty level: 3
28. $h(T)=11 \cdot 1.2^{\frac{T}{5}}$

The minimum interior relative humidity, $\boldsymbol{h}$, at which condensation occurs on a particular window varies with the exterior temperature, $\boldsymbol{T}$, in degrees Fahrenheit ( ${ }^{\circ} F$ ) according to the equation above. Which of the following statements best describes the relationship between the exterior temperature and the minimum interior relative humidity at which condensation occurs for the window?
A. It is linear because the minimum interior relative humidity increases by $\mathbf{1 . 2}$ over every $11 \circ \mathbf{F}$ interval.
B. It is linear because the minimum interior relative humidity increases by $\mathbf{1 . 2}$ over every $5 \circ \mathbf{F}$ interval.
C. It is exponential because the minimum interior relative humidity increases by $\mathbf{2 0 \%}$ over every $11 \circ \mathrm{~F}$ interval.
D. It is exponential because the minimum interior relative humidity increases by $\mathbf{2 0 \%}$ over every $5 \circ \mathbf{F}$ interval.

## Correct answer: D Difficulty level: 3

29. 

Logan is making a guitar. He measures the total length from the bridge to the nut as $\mathbf{6 5 0}$ millimeters (mm). Logan plans to put $\mathbf{2 0}$ frets, or dividers, between the nut and the bridge, starting from the nut. At first, he places each consecutive fret by subtracting $\mathbf{2 2 . 5} \mathbf{~ m m}$ from the previous length, starting with the total length from the bridge to the nut. However, after doing some research, he learns that each fret should be measured out at $\frac{17}{18}$ of the previous length. Approximately how far away from the correct location was Logan's initial placement of the $\mathbf{1 0}^{\text {th }}$ fret the first time he placed his frets?

A. 7 mm
B. 14 mm
C. 42 mm
D. 58 mm

## Correct answer: D

 Difficulty level: 330. 

A field is becoming infested with a weed. Currently, the weed has infested 150 square meters $\left(\mathrm{m}^{2}\right)$ of the field. Assuming the weed is an anemochore, the seeds will disperse with the wind and the infested area will double every two months. Otherwise, the infested area will increase by $250 \mathrm{~m}^{2}$ every month. Six months from now, which situation has the largest infested area and by how much area is it larger than the other situation in square meters?
A. If the weed is not an anemochore, the infested area is larger by $450 \mathrm{~m}^{2}$.
B. If the weed is not an anemochore, the infested area is larger by $7,950 \mathrm{~m}^{2}$.
C. If the weed is an anemochore, the infested area is larger by $450 \mathrm{~m}^{2}$.
D. If the weed is an anemochore, the infested area is larger by $7,950 \mathrm{~m}^{2}$.

## Correct answer: A Difficulty level: 3

31. $d(p)=5.04 p+19.13$

Abrasive water jets are often used as a safe, precise way of cutting natural stone. The function above relates the percent $\boldsymbol{p}$ of pores (open space) in a rock sample to the cutting depth $\boldsymbol{d}$ of the water jet, in millimeters. Which of the following statements best describes the relationship between the percent of pores and the cutting depth?
A. It is linear because the depth increases by a fixed amount for each increase of $1 \%$ in the pores.
B. It is linear because the depth increases by the same percent for each increase of $1 \%$ in the pores.
C. It is exponential because the depth increases by a fixed amount for each $1 \%$ increase in the pores.
D. It is exponential because the depth increases by the same percent for each $1 \%$ increase in the pores.
Correct answer: A Difficulty level: 3
32.

A government agency compared the number of operations research analysts (O. R. analysts) each of its departments was employing annually. When the study began (year=0), the treasury and the transportation department both employed 8 O . R. analysts. The treasury increased the number of O . R. analysts it was employing by $50 \%$ every 2 years. The transportation department employed 6 more O. R. analysts each year. What is the total number of O. R. analysts employed by the two departments at the end of the $\mathbf{6}^{\text {th }}$ year?
A. 17 O. R. analysts
B. 45 O. R. analysts
C. 71 O. R. analysts
D. 135 O. R. analysts

Correct answer: C

## Difficulty level: 3

33. 

Over a five year interval, the total value of goods, $v$, in millions of dollars traded between country $\boldsymbol{A}$ and country $\boldsymbol{B}$ increased according to the table at left where $\boldsymbol{Y}$ is the year. Which of the following correctly describes the growth in the value of goods traded over the five year interval?

| $Y$ | $v$ |
| :---: | ---: |
| 1995 | 88 |
| 1996 | 132 |
| 1997 | 198 |
| 1998 | 297 |
| 1999 | 446 |

A. The growth is exponential with the value of goods traded increasing by approximately $44 \%$ each year.
B. The growth is exponential with the value of goods traded increasing by approximately $50 \%$ each year.
C. The growth is linear with the value of goods traded increasing by approximately 44 million dollars each year.
D. The growth is linear with the value of goods traded increasing by approximately 5050 million dollars each year.

## Correct answer: B Difficulty level: 3

34. 

The table at left shows the number of bicycles that train riders brought on board In a metropolitan area. Which of the following statements best describes the relationship between the year and the number of bicycles?

| Year | Bicycles brought on train |
| :--- | ---: |
| 2004 | 1,600 |
| 2006 | 2,043 |
| 2008 | 2,609 |
| 2010 | 3,331 |
| 2012 | 4,254 |
| 2014 | 5,431 |

A. It is linear because the number of bicycles increases by the same factor every 2 years.
B. It is linear because the number of bicycles increases by the same quantity every $\mathbf{2}$ years.
C. It is exponential because the number of bicycles increases by the same factor every $\mathbf{2}$ years.
D. It is exponential because the number of bicycles increases by the same quantity every $\mathbf{2}$ years.

Correct answer: C
Difficulty level: 3
35. $D=10 \cdot 2.5^{-t}$

A heavily damped spring is released upon being stretched 10 centimeters from its equilibrium position. The distance from the spring's end to its equilibrium position, $D$, is given by the equation above where $t$ is the time in seconds after release. Which of the following best describes $D$ over time?
A. D decreases linearly and reaches 0 within four seconds.
B. D decreases linearly and never reaches 0 .
C. D decreases exponentially and reaches 0 within four seconds.
D. D decreases exponentially and never reaches 0 .

## Correct answer: D Difficulty level: 3

36. $P=-a x \cdot e^{-k x}$

A quantum physicist calculates that the potential energy, $\boldsymbol{P}$, in electron volts of an electron $\boldsymbol{x}$ nanometers from a source is calculated from the equation above where $\boldsymbol{a}>\mathbf{0}$ and $\boldsymbol{k} \geq \mathbf{0}$. If the source is an infinite plane, then $\boldsymbol{k}$ becomes $\mathbf{0}$. Which of the following correctly explains the decrease of $\boldsymbol{P}$ with respect to $\boldsymbol{x}$ when the source is an infinite plane?
A. $\boldsymbol{P}$ decreases linearly because the value of $\boldsymbol{P}$ is always negative.
B. $\boldsymbol{P}$ decreases exponentially because the value of $\boldsymbol{P}$ is always negative.
C. $\boldsymbol{P}$ decreases linearly because the constant of proportionality between $\boldsymbol{P}$ and $\boldsymbol{x}$ is negative.
D. $\boldsymbol{P}$ decreases exponentially because the constant of proportionality between $\boldsymbol{P}$ and $\boldsymbol{x}$ is negative.
Correct answer: C Difficulty level: 4
37. A metallurgist is testing the thermal conductivity of a $\mathbf{1 0 0}$ centimeter wire when it is insulated versus when it is free. The left end of the wire is kept at a temperature of $\mathbf{2 5 0}$ Kelvin (K) and the right end at a temperature of $\mathbf{3 6 0 K}$. When the wire is insulated, the temperature increases by a constant amount per centimeter from left to right. When the wire is free, the temperature increases by a constant percent per centimeter from left to right. If $\mathbf{T}_{\mathbf{I}}$ and $\mathbf{T}_{\mathbf{F}}$ are the temperatures at the midpoint of the insulated and free wire respectively, what is $\mathbf{T}_{\mathbf{I}}-\mathbf{T}_{\mathbf{F}}$ ?


## Correct answer: 5 Difficulty level: 4

38. 

Using graphical analysis, a team of video content analyzers can approximately compute the mass of displaced snow during a filmed avalanche. The chart at left shows the mass of displaced snow, $\boldsymbol{m}$, in ton $\boldsymbol{s}$ seconds after the start of the avalanche. Which of the following best describes the relationship between $\boldsymbol{m}$ and $\boldsymbol{s}$ ?

| $m$ | $s$ |
| ---: | ---: |
| 12 | 15 |
| 18 | 20 |
| 40 | 30 |
| 60 | 35 |
| 200 | 50 |

A. $\mathbf{m}$ increases exponentially by approximately $\mathbf{1 2 5}$ percent every ten seconds.
B. $\mathbf{m}$ increases linearly by approximately $\mathbf{1 2 5}$ percent every ten seconds.
C. $\mathbf{m}$ increases exponentially by approximately $\mathbf{3 1}$ tons every ten seconds.
D. $\mathbf{m}$ increases linearly by approximately $\mathbf{3 1}$ tons every ten seconds.

## Correct answer: A Difficulty level: 4

39. 

Creep is the ratio of elongation to original length that occurs in materials over time. For a particular steel structure, for the first 50 days the creep increases by $6 \cdot 10^{-6}$ per day. After the $50^{\text {th }}$ day, when the creep is $3 \cdot 10^{-4}$, the creep triples every 62 days. After the $236^{\text {th }}$ day, how much less would the creep be if it had continued to grow linearly after the $50^{\text {th }}$ day?
A. $1.1 \cdot 10^{-3}$
B. $1.4 \cdot 10^{-3}$
C. $6.7 \cdot 10^{-3}$
D. $8.1 \cdot 10^{-3}$

## Correct answer: C Difficulty level: 4

40. 

A poultry farmer has been keeping track of the number of chickens at his farm over previous years. Four years ago, the number of chickens was $\mathbf{6 4}$. The number increased by $\mathbf{5 0}$ percent each year for four years until the present day. In the future, the farmer considers the situation where the number of chickens increases at a constant rate equal to the rate of the most recent year or the situation where the number continues to increase by $\mathbf{5 0}$ percent per year. What is the difference in the number of chickens between these two situations two years from now?
A. 0
B. 189
C. 405
D. 11

## Correct answer: B Difficulty level: 4

41. 

The table at left shows low-budget airline companies' percentage share of all low-cost seats in the Philippines compared to other airline companies. Which of the following statements best describes
the growth of low-budget airlines' percentage share of low-cost seats in the Philippines?

| Year | Low-budget airlines' share of low-cost seats |
| :--- | :---: |
| 2004 | $28 \%$ |
| 2006 | $34 \%$ |
| 2008 | $43 \%$ |
| 2010 | $56 \%$ |
| 2012 | $78 \%$ |

A. The growth is approximately linear, since the percentage share of low-cost seats increases by roughly $\mathbf{1 3 \%}$ every year.
B. The growth is approximately linear, since the percentage share of low-cost seats increases by roughly $\mathbf{1 3 \%}$ every $\mathbf{2}$ years.
C. The growth is approximately exponential, since the percentage share of low-cost seats grows at an average rate of $\mathbf{4 0 \%}$ times the per year.
D. The growth is approximately exponential, since the percentage share of low-cost seats grows at an average rate of $\mathbf{4 0 \%}$ times every $\mathbf{2}$ year.
Correct answer: D Difficulty level: 3
42.

A team of geologists creates a borehole to record the temperature within the Earth's crust. The temperature, $\boldsymbol{T}$, in degrees Fahrenheit $(\boldsymbol{\circ} \boldsymbol{F})$ is recorded along with the depth, $\boldsymbol{D}$, in kilometers ( $\boldsymbol{k m}$ ) in the table at left. Which of the following best explains the relationship between $\boldsymbol{D}$ and $\boldsymbol{T}$ ?
A. The relationship is approximately linear because $\boldsymbol{D}$ and $\boldsymbol{T}$ are directly proportional.
B. The relationship is approximately exponential because $\boldsymbol{D}$ and $\boldsymbol{T}$ are directly proportional.
C. The relationship is approximately linear because the rate of increase in $\boldsymbol{T}$ with respect to $\boldsymbol{D}$ is constant.
D. The relationship is approximately exponential because the rate of increase in $\boldsymbol{T}$ with respect to $\boldsymbol{D}$ is constant.
Correct answer: C Difficulty level: 3
43. $V(m)-V(m-1)=622$

The value, $V(m)$, in dollars of a particular house $m$ months after purchase follows the equation given above where $m$ is a positive integer. Which of the following statements best describes the value of the house over time?
A. The value of the house increases linearly.
B. The value of the house decreases linearly.
C. The value of the house increases exponentially.
D. The value of the house decreases exponentially.

Correct answer: A Difficulty level: 3
44.

A digital camera determines the amount of green light present based on the micromoles ( $\mu \mathrm{mol}$ ) of photo-electrons detected by exposure. A programmer creates a function that defines a G-value from 0 to 255 to the corresponding pixel, as shown in the table at left. Which of the following best describes the relationship between the number of photo-electrons detected and the G-value?

| Photo-electrons ( $\mu \mathrm{mol}$ ) | G-value (RGB light units) |
| :--- | ---: |
| 0.025 | 43 |
| 0.05 | 85 |
| 0.075 | 128 |
| 0.1 | 170 |
| 0.125 | 213 |
| 0.15 | 255 |

A. It is approximately linear, because the G-value increases by approximately 42.5 light units with each $0.025 \mu \mathrm{~mol}$ increase in photo-electrons.
B. It is approximately linear because the G-value approximately doubles with each $0.025 \mu \mathrm{~mol}$ increase in photo-electrons.
C. It is approximately exponential because the G-value approximately doubles with each $0.025 \mu \mathrm{~mol}$ increase in photo-electrons.
D. It is approximately exponential because the G-value approximately increases by $20 \%$ with each $0.025 \mu \mathrm{~mol}$ increase in photo-electrons.
Correct answer: A Difficulty level: 3
45.

An economist uses two models, $\boldsymbol{V}_{1}$ and $\boldsymbol{V}_{2}$, to value a foreign currency in dollars. $\boldsymbol{V}_{\boldsymbol{1}}$ has a value of $\boldsymbol{A}$ today and increases by $0.1 \boldsymbol{A}$ every year in the future, where $\boldsymbol{A}$ is a constant. $\boldsymbol{V}_{2}$ has a value of B today and quadruples every $\boldsymbol{k}$ years in the future, where $\boldsymbol{B}$ and $\boldsymbol{k}$ are positive constants. Both models take the same amount of time to double in value from today. What is the value of $\boldsymbol{k}$ ?
$\square$

## Correct answer:20

## Difficulty level: 3

46. 

In 2000, there were $\mathbf{0 . 0 2 5}$ phone subscriptions per inhabitant in Africa each for mobile and fixed phones. After that, the fixed phone subscriptions steadily increased by 0.01 per 7 years, while the mobile phone subscriptions grew $\mathbf{4 8 \%}$ per year. What was the total number of phone subscriptions per inhabitant in 2002?
A. 0.027
B. 0.034
C. 0.073
D. 0.083

## Correct answer: D Difficulty level: 4

47. 

The earnings per share of stock in a company grew $\mathbf{7 0 \%}$ per year for a decade, reaching $\mathbf{\$ 2 7}$ per share in 2011. Knowing that such growth is not sustainable, the adviser makes a prediction for 2014 based on the average rate of change, which was $\$ 3$ per year. To the nearest dollar, how much higher would the financial adviser's prediction be for 2014 if the adviser assumed the earnings would continue to grow $\mathbf{7 0 \%}$ per year?


## Correct answer: 97

## Difficulty level: 4

48. 

Mandisa is a lawyer considering two salary rates at two different law firms. At law firm $A$, her salary increases by 20 percent every two years. At law firm $B$, her salary increases by a constant amount every year equal to 10 percent of her initial salary. She starts with the same initial salary at both firms. After six years, what is the value of her future salary at firm $A$ divided by her future salary at firm $B$ rounded to the nearest hundredth?
A. 0.90
B. 0.98
C. 1
D. 1.08

Correct answer: D Difficulty level: 4
49.

The cumulative costs of a tankless water heater and tank water heater are \$4,090 each at the end of the $7^{\text {th }}$ year of use. The cumulative costs of the tankless heater increase $\$ 180$ per year, but for the tank heater, they increase by $11 \%$ per year. By the end of the $10^{\text {th }}$ year, about how much more will the cumulative costs of the tank heater be than of the tankless heater?
A. $\$ 964$
B. $\$ 1,504$
C. $\$ 4,625$
D. $\$ 5,723$

## Correct answer: A Difficulty level: 4

50. 

In a particular science research database, the number of indexed genetics articles had increased by an average of $\mathbf{3 0 7}$ articles per year for several years. If there were $\mathbf{6 0 0 0}$ genetics articles indexed at the end of that time, and the number of articles increased by $\mathbf{8 \%}$ annually since then, how many
more articles would be indexed than the average annual increase would predict by $\mathbf{2}$ years later? Round to the nearest article.


Correct answer: 384

## Difficulty level: 4

51. 

A state accountant models that sales tax revenue grew about $\mathbf{1 5 \%}$ per year for several years. Then $\mathbf{2}$ years ago, when the revenue was $\mathbf{\$ 2 . 1}$ billion, the revenue began growing by $\mathbf{\$ 1 7 9 . 5}$ million per year instead. About how much less would the revenue be this year than if it had continued growing $\mathbf{1 5 \%}$ per year?
A. $\$ 136$ million
B. $\$ 318$ million
C. $\$ 2.05$ million
D. $\$ 5.24$ million

Correct answer: B Difficulty level: 4
52.

An auto repair company is advertising on television and on the internet. It hires a statistician to poll $\mathbf{5 0 0 0}$ people across the country at the beginning of every month for six months. Eight hundred people saw the advertisement on television at the beginning of the first month with an increase of $\mathbf{2 0 0}$ people each month. Also, $\mathbf{1 0 0 0}$ people saw the advertisement on the internet at the beginning of the first month with an increase of $\mathbf{x}$ percent each month. At the beginning of the third month, there were $\mathbf{2 4 0}$ more people who saw the advertisement on the internet than on television. To the nearest percent, what is the value of $\mathbf{x}$ ?


## Correct answer: 20

## Difficulty level: 4

53. 

At first, the number of users who used a program increased by $\mathbf{1 0 \%}$ per month. When the number of users reached $\mathbf{9 5}$ thousand, the program had saturated its market and began losing users at a rate of $\mathbf{1 , 0 0 0}$ users per month. If the number of users had continued to grow like it had at first, about how many more users would there have been $\mathbf{3}$ months later?
A. 22.7 thousand users
B. 28.4 thousand users
C. 31.5 thousand users
D. 34.4 thousand users

Correct answer: D
Difficulty level: 4

## 54.

While Deniz used a computer program, she was learning and remembering an average of $\mathbf{1 0}$ new French vocabulary words per day. After she had learned $\mathbf{5 0 0}$ words, she stopped using the program. She began to forget $\mathbf{4 0 \%}$ of her French words every 5 days. Given the information above, how many more French vocabulary words would Deniz have remembered after $\mathbf{1 5}$ days if she had continued using the program?

## Correct answer: 542

## Difficulty level: 4

55. $\frac{f(t-1)}{f(t)}=1.0044$

A mechanical engineer is simulating the rupture of a water tank by puncturing a duplicate water tank and analyzing the water flow. The engineer notices that the rate of water flow, $\boldsymbol{f}(\boldsymbol{t})$, in liters per second $\boldsymbol{t}$ seconds after puncturing satisfies the equation shown above. Which of the following statements best describes the rate of water flow over time?
A. The rate of water flow increases linearly.
B. The rate of water flow decreases linearly.
C. The rate of water flow increases exponentially.
D. The rate of water flow decreases exponentially.

## Correct answer: D Difficulty level: 3

56. 

A food safety specialist uses a sensor to detect and measure small electrical currents, in order to determine the concentration of aspartame in soft drinks. The table at left relates the current, in nanoamperes ( $\mathbf{n A} \mathbf{A}$ ), the sensor detected to the concentration of aspartame, in micromoles per liter $\left(\frac{\mu m o l}{L}\right)$. Which of the following statements best describes the relationship?

| Current $(\mathrm{nA})$ |
| ---: |
| Concentration of Aspartame $\left(\frac{\mu \mathrm{mol}}{\mathrm{L}}\right)$ |
| 10 |
| 0 |
| 110 |
| 160 |
| 210 |
| 260 |
| 310 |

A. It is approximately linear because the concentration increases by about the same amount for each $\mathbf{5 0 n A}$ increase in current.
B. It is approximately linear because the concentration increases by about the same percent for
each 50 nA increase in current.
C. It is approximately exponential because the concentration increases by about the same amount for each 50 nA increase in current.
D. It is approximately exponential because the concentration increases by about the same percent for each 50 nA increase in current.

## Correct answer: A Difficulty level: 3

## 57.

A company bought a year of search engine optimization services (SEO) for their site. During that time, the number of visitors per month grew $\mathbf{2 0 \%}$ per month, with $\mathbf{5 0 0}$ visitors the final month. After the SEO ended, the site gained $\mathbf{2 5}$ visitors per month. How many fewer visitors did the site have $\mathbf{3}$ months after the SEO ended than there would have been if the number had continued to grow $\mathbf{2 0 \%}$ per month?

## Correct answer: 289

## Difficulty level: 3

58. 

Scarlett is studying neuron degeneration in mice. One article suggests that the number of neurons remaining, $N(t)$, after $t$ months is modeled by the following function:
$\mathrm{N}(\mathrm{t})=\mathrm{N}_{0} \cdot(1-r)^{t / \tau}$
where $\mathrm{N}_{0}$ is the initial number of neurons at time $\boldsymbol{t}=\mathbf{0}, \boldsymbol{r}$ is the degeneration rate $(\mathbf{0}<\boldsymbol{r}<\mathbf{1})$, and $\boldsymbol{\tau}$ is the characteristic timescale of the decay process, measured in months. If the characteristic timescale $\tau$ is $\mathbf{4}$ months, which of the following statements best describes the relationship between the number of neurons remaining and the number of months?
A. The relationship is linear because every 4 months, the number of neurons remaining decreases by a fixed amount.
B. The relationship is linear because every month, the number of neurons remaining increases by a fixed amount.
C. The relationship is exponential because every 4 months, the number of neurons remaining decreases by an amount proportional to the previous 4 months.
D. The relationship is exponential because every month, the number of neurons remaining increases by an amount proportional to the previous month.

## Correct answer: C Difficulty level: 3

## Data inferences

## 1.

A random sample of 35 four-door passenger vehicles had a mean gas mileage, in miles per gallon ( mpg ), of 25.9 mpg . The estimate had a margin of error of 2.6 mpg at a $98 \%$ confidence level. Of the following, which is most plausible value for the true mean of the mileage of four-door passenger vehicles in general?
A. 24 mpg
B. 29 mpg
C. 32 mpg
D. 35 mpg

Correct answer: A Difficulty level: 2
2.

Based on random samples of river heights, oceanographers estimate that $\mathbf{4 , 8 0 0}$ cubic kilometers $\left(\mathbf{k m}^{\mathbf{3}}\right)$ of freshwater is discharged into the Arctic Ocean annually. The estimate has a margin of error of $\mathbf{2 4 0} \mathbf{~ k m}^{\mathbf{3}}$ at the $\mathbf{9 0} \%$ confidence level. Which of the following is the most reasonable claim about the volume of freshwater discharged annually into the Arctic Ocean?
A. It is between 4,800 and $5,040 \mathbf{k m}^{3}$.
B. It is between 4,560 and $5,040 \mathbf{~ k m}^{3}$.
C. It is between 240 and $4800 \mathbf{k m}^{3}$.
D. It is between 240 and $4320 \mathbf{k m}^{3}$.

## Correct answer: B

Difficulty level: 2
3.

A survey of $\mathbf{9 , 0 0 0}$ randomly selected dentists practicing in the United States (US) found that $\mathbf{3 , 6 0 0}$ of them used text messaging to remind clients of upcoming appointments. If there were $\mathbf{1 4 7 , 0 0 0}$ practicing dentists in the US, approximately how many of them used text messaging for that purpose?
A. 12,600 dentists
B. 58,800 dentists
C. 159,600 dentists
D. 367,500 dentists

Correct answer: B

## Difficulty level: 2

4. 

A random sample of international flights in 2013 showed that $\mathbf{7 9 \%}$ of the flights arrived within $\mathbf{1 5}$ minutes of their scheduled arrival time, and this estimate had a margin of error of $\mathbf{3 \%}$ at a $\mathbf{9 5 \%}$ confidence level. Which of the following conclusions is best?
A. Exactly $\mathbf{7 9 \%}$ arrived within $\mathbf{1 5}$ minutes of their scheduled times.
B. Exactly $\mathbf{7 6 \%}$ arrived within $\mathbf{1 5}$ minutes of their scheduled times.
C. Between $\mathbf{7 6 \%}$ and $\mathbf{8 2 \%}$ arrived within $\mathbf{1 5}$ minutes of their scheduled times.
D. Between $\mathbf{9 2 \%}$ and $\mathbf{9 8 \%}$ arrived within $\mathbf{1 5}$ minutes of their scheduled times.

Correct answer: C Difficulty level: 2
5.

In a poll of $\mathbf{1 , 5 7 8}$ randomly selected American adults, $\mathbf{4 4 . 8 \%}$ of the respondents said that airlines should allow in-flight calls on airplanes. The results had a margin of error of $\mathbf{2 . 5 \%}$ at a $\mathbf{9 0 \%}$ confidence level. Which of the following is most likely to be equal to the percentage of all American adults who would say that airlines should allow in-flight calls?
A. $40 \%$
B. $43 \%$
C. $48 \%$
D. $90 \%$

## Correct answer: B Difficulty level: 2

## 6.

In a study of 40 randomly selected captive Octopus vulgaris, researchers found that the octopi could learn to integrate visual and tactile information to find food after a mean of $\mathbf{1 1 9}$ trials. The estimate had a margin of error of $\mathbf{1 8}$ trials at a $\mathbf{9 5 \%}$ confidence level. Which of the following is the most reasonable conclusion about the number of trials it would take all captive Octopus vulgaris in general to learn to find the food?
A. The evidence suggests that half of them would require 119 or fewer trials.
B. The evidence suggests that the mean number of trials would be $\mathbf{1 1 9}$ trials.
C. The evidence suggests that the mean number of trials would be between $\mathbf{1 1 9}$ and $\mathbf{1 3 7}$ trials.
D. The evidence suggests that the mean number of trials would be between 101 and $\mathbf{1 3 7}$ trials.

## Correct answer: D Difficulty level: 3

7. 

Researchers measured the heart rates of several randomly selected astronauts exercising on stationary bicycles during long-term space missions. The researchers found the mean heart rate of the astronauts was $\mathbf{1 5 5}$ beats per minute with a margin of error of $\mathbf{1 2}$ beats per minute at a $\mathbf{9 0 \%}$ confidence level. Which of the following is the most plausible value for the mean heart rate of all astronauts exercising on stationary bicycles during long-term space missions?
A. 130 beats per minute
B. 140 beats per minute
C. 160 beats per minute
D. 175 beats per minute

Correct answer: C
Difficulty level: 3

## 8.

In a poll of $\mathbf{1 4 , 6 9 7}$ randomly selected adults in the United States, those polled spent an average of $\mathbf{\$ 9 5}$ per day in November of last year, as compared with $\mathbf{\$ 9 1}$ per day in November two years ago. The estimates had a margin of error of $\mathbf{\$ 4}$ at the $\mathbf{9 5 \%}$ confidence level. Which of the following is a reasonable claim to make based on this sample?
A. All adults in the United States spent between $\mathbf{\$ 9 1}$ and $\mathbf{\$ 9 9}$ daily last November.
B. $\mathbf{9 5 \%}$ of adults in the United States spent between $\mathbf{\$ 9 1}$ and $\$ \mathbf{9 9}$ daily last November.
C. It is plausible that average daily spending of adults in the United States remained the same in November of last year as it was in November two years ago.
D. Between $\mathbf{9 1 \%}$ and $\mathbf{9 9 \%}$ of adults in the United States spent $\$ \mathbf{4}$ more daily last November than in November two years ago.
Correct answer: C Difficulty level: 3
9.

In a particular county, a sample of the population showed that $\mathbf{8 4} \%$ of the households lived in the same residence as they had the previous year. The estimate had a margin of error of $\mathbf{1 . 5 \%}$ at the $\mathbf{9 0 \%}$ confidence level. If the county has $\mathbf{5 0 , 0 0 0}$ households, which of the following best estimates the number of households that lived in the same residence as they had the previous year, at the $\mathbf{9 0 \%}$ confidence level?
A. $\mathbf{3 4 , 5 0 0}$ to $\mathbf{4 9 , 5 0 0}$ residents
B. $\mathbf{3 7 , 5 0 0}$ to $\mathbf{5 0 , 0 0 0}$ residents
C. $\mathbf{4 1 , 2 5 0}$ to $\mathbf{4 2 , 7 5 0}$ households
D. $\mathbf{4 4 , 2 5 0}$ to $\mathbf{4 5 , 7 5 0}$ households

## Correct answer: C Difficulty level: 3

10. 

Prior to the 2014 elections, 1,000 randomly selected Louisiana voters were surveyed about what single issue would most likely influence their vote. Of those surveyed, $\mathbf{5 6 0}$ voters answered that the state of the economy would most influence their vote. Based on this information, which statement about all voters in Louisiana is most appropriate?
A. Exactly $\mathbf{5 6 \%}$ of all Louisiana voters thought the state of the economy would most influence their voting.
B. Approximately $\mathbf{5 6 \%}$ of all Louisiana voters thought the state of the economy would most influence their voting.
C. Exactly $\mathbf{5 6 \%}$ of Louisiana voters would vote for the candidate with the best plan to improve the economy.
D. Approximately $\mathbf{5 6 \%}$ of Louisiana voters would vote for the candidate with the best plan to improve the economy.

## Correct answer: B <br> Difficulty level: 3

11. 

A bottling company sells bottles of water. A random sample of $\mathbf{5 0}$ water bottles found that the bottles contained, on average, $\mathbf{0 . 9 6}$ liters of water, and the estimate had a margin of error of $\mathbf{0 . 0 8}$ liters at the $\mathbf{9 5 \%}$ confidence level. Which of the following is a reasonable claim to make based on this sample?
A. The company always fills its water bottles with less than 1 liter of water.
B. The company usually fills its water bottles with between $\mathbf{0 . 9 6}$ liters and $\mathbf{1 . 0 4}$ liters of water.
C. The company always fills its water bottles with between $\mathbf{0 . 8 8}$ liters and $\mathbf{1 . 0 4}$ liters of water.
D. It is plausible that, on average, the company fills its water bottles with $\mathbf{1}$ or more liters of water.

## Correct answer: D Difficulty level: 4

## 12.

An archaeologist uses an accelerator mass spectrometer to find the age of a buried branch. At the $\mathbf{6 8 \%}$ confidence level, the spectrometer estimates that the branch was $\mathbf{1 0 , 0 0 0}$ years old with a margin of error of $\mathbf{2 0 0}$ years. Which of the following could the spectrometer estimate as the age of the branch at the $\mathbf{9 5 \%}$ confidence level?
A. 9,500 years old, with a margin of error of $\mathbf{5 0 0}$ years
B. $\mathbf{1 0 , 0 0 0}$ years old, with a margin of error of $\mathbf{4 0 0}$ years
C. $\mathbf{9 , 5 0 0}$ years old, with a margin of error of $\mathbf{5 0}$ years
D. $\mathbf{1 0 , 0 0 0}$ years old, with a margin of error of $\mathbf{4 0}$ years

## Correct answer: B Difficulty level: 4

13. 

A random sample of $\mathbf{5 0 0}$ residents of a town included $\mathbf{1 7 3}$ residents who primarily spoke a language other than English at home, with a margin of error of $\mathbf{2 5}$ residents and a confidence level of $\mathbf{9 8 \%}$. If the town has $\mathbf{2 5 , 0 0 0}$ residents, how many residents primarily speak a language other than English at home, with the $\mathbf{9 8 \%}$ confidence level?
A. 7,400 to $\mathbf{9 , 9 0 0}$ residents
B. 8,625 to $\mathbf{8 , 6 7 5}$ residents
C. $\mathbf{2 4 , 4 7 5}$ to $\mathbf{2 4 , 5 2 5}$ residents
D. 23,250 to 25,750 residents

Correct answer: A Difficulty level: 4
14.

In the National Health and Nutrition Examination Survey, $\mathbf{8 0 . 5 \%}$ of the participants had healthy levels of high-density lipoprotein (HDL) cholesterol, the estimate has a margin of error of $\mathbf{1 . 5 \%}$ at a confidence level of $\mathbf{9 5 \%}$. The participants were a random sample of United States (US) residents. If the US population at the time of the study was $\mathbf{3 1 6}$ million people, what is the estimate at a $\mathbf{9 5 \%}$ confidence level of the number of people in the US who had healthy levels of HDL cholesterol?
A. 237 million to 246 million people
B. 245 million to 264 million people
C. 250 million to 259 million people
D. 254 million to 300 million people

Correct answer: C Difficulty level: 4
15.

A university had 150 students registered for an introductory sociology class. The students were randomly assigned to either a section taught with case studies or with lectures. Both sections took the same final exam. Both margins of error are at a $\mathbf{9 0 \%}$ confidence level. Which of the following conclusions is the most reasonable regarding the sociology class?

| Teaching method | Final exam average | Margin of error |
| :--- | :--- | :--- |
| Case studies | $87 \%$ | $2 \%$ |
| Lecture | $89 \%$ | $2 \%$ |

A. The university should only offer the lecture teaching method, because students in that section had a higher final exam average.
B. The university should not offer either teaching method, case studies or lectures, because neither section achieved the target $\mathbf{9 0 \%}$ average.
C. The university should only offer the lecture teaching method, because the final exam average plus the margin of error achieved the target $\mathbf{9 0 \%}$.
D. The university does not have strong evidence to indicate which teaching method is more effective.
Correct answer: D Difficulty level: 4

## Center, spread, and shape of distributions

1. 

The number of telephone lines in each country in Central America and the Carribean is shown above in a dot plot. The number of telephone lines in each country has been rounded to the nearest 250 thousand. According to the dot plot, what is the median number of telephone lines (in thousands)?



Correct answer: 0
Difficulty level: 2
2.

In the dot plot above, the length of the coastline of each country in South America is shown in thousands of kilometers ( $1000-\mathrm{km}$ ), rounded to the nearest thousand kilometers. According to the dot plot, what is the mean length of coastline, in thousands of kilometers?


Correct answer: 2
Difficulty level: 2

## 3.

During a five-day period, Marta served a different number of customers at her flower shop each day. The mean number of daily customers served during this period was 17. In the following month, during the same five-day period, she served $\mathbf{1 6}$ customers for four of the days, but on the fifth day, she served 25 customers. What is the difference between the means of the number of customers she served during the two five-day periods?
A. 0.8
B. 1.0
C. 2.4
D. The two means are equal.

## Correct answer: A

## Difficulty level: 2

## 4.

The table above shows the annual average per pupil educational expenditures in the United States from 2008 through 2012. What is the range of the per pupil expenditures?

| Year | 2008 | 2009 | 2010 | 2011 | 2012 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Per pupil expenditure | $\$ 11,223$ | $\$ 11,665$ | $\$ 11,824$ | $\$ 11,864$ | $\$ 11,735$ |



## Correct answer: 641

## Difficulty level: 2

## 5.

The box plot above summarizes the resting heart rates, in beats per minute, of the members at a gym. What is the range of resting heart rates?

Resting heart rates (beats per minute)

A. 16 beats per minute
B. 31 beats per minute
C. 62 beats per minute
D. 70 beats per minute

## Correct answer: C

## Difficulty level: 2

6. 

The box-and-whisker plot above shows the average outdoor temperature of a North American City
at noon, in degrees Fahrenheit, for each month of the year. What is the range of the temperatures?


Average monthly temperature (in degrees Fahrenheit)
A. 17
B. 27
C. 61
D. 111

Correct answer: C Difficulty level: 2
7.

A census was taken in 11 African countries. For each country, the amount of the population that had access to water from the water supply industry was computed and recorded to the nearest 5 percent. This amount was expressed as a percentage of the total population and plotted above. According to the dot plot, what is the range of these percentages?
Percentage of population supplied by water supply industry

$0 \quad 5101520253035404550556065707580859095100$


## Correct answer: 70

## Difficulty level: 2

## 8.

The number of employees in each industry in Seattle was recorded and rounded to the nearest 10 thousand. The results are displayed in the dot plot above. According to the dot plot, what is the median number of employees, in thousands?

9.

Data was taken on carpooling in Tallahassee, Florida. For each person's daily commute, the number of people in the car was recorded. The results are summarized in the bar graph at left. What is the median number of people in the car?

$\square$

## Correct answer: 1

Difficulty level: 2
10.

Daily rainfall in centimeters was recorded over a 41-year period in Turramurra. For each year, the day with the most rain in centimeters was plotted above according to its amount of rainfall to the nearest 2 centimeters. According to the dot plot, what is the maximum amount of rainfall that was ever recorded in a single day in Turramurra, in centimeters?


Maximum rainfall for the year (in centimeters)
$\square$

## Correct answer: 38

Difficulty level: 2
11.

The annual natural gas production of the Middle Eastern countries is recorded in the dot plot above. Each value is rounded to the nearest 10 billion cubic meters. According to the dot plot,
what is the median annual natural gas production, in billions of cubic meters?


Correct answer: 10
Difficulty level: 2
12.

A linguistics library contains several archives of language samples. The table above gives the number of distinct languages referenced in each archive. What is the range of numbers of distinct languages referenced?

| Archive | Number of distinct languages |
| :--- | :--- |
| Archive A | 111 |
| Archive B | 3 |
| Archive C | 136 |
| Archive D | 26 |
| Archive E | 53 |
| Archive F | 258 |
| Archive G | 17 |



## Correct answer: 255

## Difficulty level: 2

13. 

On a message board, participants listed words whose letters are all in alphabetical order, such as "almost." The table at left lists the number of words they listed with each letter count. What was the median letter count of the words they listed?

| Letter count | Number of words listed |
| :--- | ---: |
| 4 letters | 12 |
| 5 letters | 49 |
| 6 letters | 12 |
| 7 letters | 9 |
| 8 letters | 1 |

$\square$

## Correct answer: 5

## Difficulty level: 2

14. 

A police officer recorded the travel speeds, in miles per hour, of traffic on a major arterial road. The histogram to the left shows the number of vehicles driving at each speed. Which statement best compares the mean and the median of the data?

A. There is no mean value for this data.
B. The mean is greater than the median.
C. The median is greater than the mean.
D. The mean and median are approximately equal.

## Correct answer: D <br> Difficulty level: 3

15. 

In San Jose, the amount of time it took each person to get to work was recorded and rounded up to the nearest 5 minutes. The data collected for men and women are shown in the bar graph to the left. According to the bar graph, which of the following comparisons is true?

A. The mean travel time for men is greater than the mean travel time for women.
B. The mean travel time for women is greater than the mean travel time for men.
C. The median travel time for men is greater than the median travel time for women.
D. The median travel time for women is greater than the median travel time for men.

## Correct answer: A

Difficulty level: 3
16.

The table at left partially reports the numbers of civil aircraft produced in the United States during the course of $\mathbf{5}$ months. If there was a mean of $\mathbf{3 2 5}$ civil aircraft produced during that time, how many were produced in month B ?

| Month | Civil aircraft produced |
| :---: | ---: |
| A | 400 |
| B | $?$ |
| C | 286 |
| D | 350 |
| E | 290 |



## Correct answer: 299

 Difficulty level: 317. 

Adult workers in Los Angeles Country were surveyed to see how many vehicles were available in their household. Data was taken separately for males and females in order to compare them.

According to the bar graph to the left, which of the following is true?


Number of vehicles available in person's household
A. The median number of vehicles available to females is greater than the median number of vehicles available to males.
B. The median number of vehicles available to males is greater than the median number of vehicles available to females.
C. The median number of vehicles available to females is equal to the median number of vehicles available to males.
D. There is not enough information to compare the median number of vehicles available to females and males.

## Correct answer: C <br> Difficulty level: 3

18. 

For each of the largest 21 airline companies in Europe, the average delay of flights was calculated and shown in the dot plot above. If we remove the two airlines with the highest flight delays from the dot plot, which of the following will result?

A. The mean will decrease only.
B. The mean and range will decrease only.
C. The mean and median will decrease only.
D. The mean, median, and range will decrease.

Correct answer: B
Difficulty level: 3
19.

A class tested their reaction times to catch a falling object. The dot plot above gives their results, to the nearest tenth of a second. Which statement best compares the median and the mean for this data?

Reaction time in seconds

A. The mean is greater than the median.
B. The median is greater than the mean.
C. The mean and the median are about the same.
D. There is not enough information to determine the mean

## Correct answer: A <br> Difficulty level: 3

20. 

The cost of each house in New Mexico is summarized in the histogram to the left. Houses that are worth more than 1 million dollars are not shown due to space limitations. Above 1 million dollars, the number of houses continues to decrease steadily as the cost increases. What is the range of house costs?

A. 0
B. 150 thousand
C. 1,000 thousand
D. There is not enough information to determine the range.

## Correct answer: D <br> Difficulty level: 3

21. 

The age distributions of males and females in Chicago is shown in the bar graph at left. People aged 19 or younger are called "children," people aged 20 to 59 are called "adults," and people aged 60 or older are called "seniors." According to the data shown, which of the following is true?

A. The percentage of male children is less than the percentage of female children, but the percentage of male adults is greater than the percentage of female adults.
B. The percentage of male children is greater than the percentage of female children, and the percentage of male adults is greater than the percentage of female adults.
C. The percentage of male children is less than the percentage of female children, but there is not enough information to compare the percentage of male adults to the percentage of female adults.
D. The percentage of male children is greater than the percentage of female children, but there is not enough information to compare the percentage of male adults to the percentage of female adults.

## Correct answer: B Difficulty level: 3

22. 

Students at schools in different states calculated the volume of snow that it took to fill one cup of water after the snow had melted. Their results, in cups, were:

$$
3.7, \quad 3.0, \quad 3.9, \quad 2.5, \quad 2.5, \quad 2.2
$$

To the nearest tenth of a cup, how much greater was the mean than the median of their calculations?


Correct answer: 1/5
Difficulty level: 3
23. The table at left partially summarizes the percent of residents in different counties who participate in performing arts at least once a month. The percentages have a range of $12.9 \%$. What could be the percentage of county $G$ residents who participate in performing arts at least once a month?

| County | Percentage |
| :---: | ---: |
| A | $9.8 \%$ |
| B | $8.8 \%$ |
| C | $7.8 \%$ |
| D | $5.2 \%$ |
| E | $17.3 \%$ |
| F | $4.7 \%$ |
| G | $?$ |
| H | $4.7 \%$ |



Correct answer: 22/5 or 88/5
Difficulty level: 3
24.

In a large city, each home was surveyed to see how many rooms it had. The bar graph at left shows the results. If a construction company in the city were to build 22,000 4-room homes, the median number of rooms would decrease byl. Due to a shortage of supplies, the construction company decides to build 22,0003 -room homes instead. These are the only homes being built, so the data is not affected by anything else. By how much will the median number of rooms decrease?

$\square$

## Correct answer: 1

## Difficulty level: 3

25. 

Elena mailed 6 packages, with the following shipping charges.
$\$ 6.15, \quad \$ 4.78$. $\quad \$ 5.61, \quad \$ 4.41, \quad \$ 4.21, \quad \$ 6.54$
If she mails a $7^{\text {th }}$ package for $\$ 5.61$, how will that affect the median shipping charge?
A. The median will remain the same.
B. The median will increase by $\$ 0.05$.
C. The median will increase by $\$ 0.41$.
D. The median will increase by $\$ 0.60$.

Correct answer: C
Difficulty level: 3
26.

Both dot plots to the left show the years on which various New Zealand wineries were founded. The first dot plot rounds these values to the nearest $\mathbf{1 0}$ years and the second dot plot rounds these values to the nearest 20 years. If we calculate the mean, median, and range based on each of the dot plots and not from the original data used to generate them, which of them will differ from the first dot plot to the second?

A. None will differ.
B. Mean only
C. Mean and median only
D. Mean, median, and range

Correct answer: C

## Difficulty level: 3

27. 

For each of the $\mathbf{1 5}$ countries in the Middle East, the percentage of the labor force in agriculture was recorded to the nearest $\mathbf{5}$ percent. This data is shown in the dot plot above. Based on the shape of the data, which of the following correctly compares the mean and the median?
A. The mean is less than the median.
B. The mean is greater than the median.
C. The mean is equal to the median.
D. There is not enough information to compare the mean and the median.

Correct answer: B
Difficulty level: 3
28.

The editors of a newspaper want a proportional number of articles about fine and performing arts to those in the $\mathbf{2 0}$ best-selling US newspapers. They calculate that they need $\mathbf{2 4}$ such articles per month in their own paper. The dot plot above shows the number of fine and performing arts articles in their paper each month. How many fine and performing arts articles does the newspaper need in the $\mathbf{1 2}{ }^{\text {th }}$ month in order to have a mean of $\mathbf{2 4}$ such articles per month?


Fine and Performing Arts Articles per Month
A. 22 articles
B. 24 articles
C. 25 articles
D. 29 articles

## Correct answer: D <br> Difficulty level: 3

29. 

The box-and-whisker plots at left show data on the heights, in meters, of all waves measured at an ocean beach on two separate days. What is the difference of the median wave height from day $\mathbf{1}$ and the median wave height from day $\mathbf{2}$, in meters?

$\square$

Correct answer: 0.4
Difficulty level: 3
30.

In New Mexico, the number of bedrooms in each house is recorded and shown in the bar graph to the left. The rightmost category combines all houses with at least 5 bedrooms in it. According to the bar graph, what can we say about the mean number of bedrooms in New Mexico houses?

A. The mean is less than 3 .
B. The mean is greater than 3 .
C. The mean is equal to 3 .
D. There is not enough information to compare the mean to 3 .

## Correct answer: D <br> Difficulty level: 3

31. 

In San Jose, the time that people left home in the morning was recorded and is shown in the bar graph to the left to the nearest $\mathbf{3 0}$ minutes. Times before 5:30 a.m. or after 9:00 a.m. were not included in the data. According to the data shown, which of the following comparisons between the male and female population is correct?

A. The range of time leaving home for females is greater than the range of time leaving home for males.
B. The range of time leaving home for males is greater than the range of time leaving home for females.
C. The mean time leaving home for females is greater than the mean time leaving home for males.
D. The mean time leaving home for males is greater than the mean time leaving home for females.

## Correct answer: C Difficulty level: 3

32. 

The students in Juan's math class have the exact same mean height as the students in Juan's English class. However, while the standard deviation of the student heights in his math class is $\mathbf{3 . 2}$ inches, the standard deviation of the student heights in his English class is $\mathbf{6 . 1}$ inches. Which of the following statements must be true?
A. The mean height of the students in Juan's English class is 2.9 inches greater than the mean height of the students in Juan's math class.
B. The median height of the students in Juan's English class is $\mathbf{2 . 9}$ inches greater than the median height of the students in Juan's math class.
C. The heights of the students in Juan's math class are more variable than the heights of the students in Juan's English class.
D. The heights of the students in Juan's math class are less variable than the heights of the students in Juan's English class.
Correct answer: D
Difficulty level: 3
33.

An environmental biologist recorded the numbers of snail eggs in the first clutch (group) laid at different temperatures, as shown in the histograms to the left. At $\mathbf{2 2 C}$, the snails laid a mean of 49 eggs. At $\mathbf{2 5 C}$, they laid a mean of $\mathbf{3 1}$ eggs. Which statement best compares the standard deviations of the numbers of eggs?


Number of eggs in first clutch at $22^{\circ} \mathrm{C}$


Number of eggs in first clutch at $25^{\circ} \mathrm{C}$
A. Both sets vary too much to have a valid standard deviation.
B. The standard deviation is greater when the first clutch is at $\mathbf{2 2} \boldsymbol{C}$.
C. The standard deviation is greater when the first clutch is at $\mathbf{2 5} \boldsymbol{C}$.
D. The standard deviations at both temperatures are about the same.

Correct answer: B
Difficulty level: 3
34.

The number of structures built in each decade in Denver County is shown in the histogram to the left. Data for years before $\mathbf{1 9 4 0}$ or after $\mathbf{2 0 0 9}$ was not collected. Which of the following statements about the shape of the number of structures built is true?

A. It is bell-shaped because most structures were built in the 1950-1959 decade.
B. It is bell-shaped because most structures were built in the 1970-1979 decade.
C. There is little variance in the shape.
D. There is a lot of variance in the shape.

## Correct answer: D

Difficulty level: 3
35.

The box plot above depicts the numbers of law degrees (JD or LL.B), in thousands, conferred each year in the United States over a span of 49 years. No two years had duplicate numbers of degrees conferred. If the next year, there were 46 thousand degrees conferred, how would that affect the range, mean, and median of the numbers?

Thousands of Law Degrees Conferred Annually in the United States

A. Only the range would increase.
B. Only the range and mean would increase.
C. The range, median, and mean would all increase.
D. The range and median would increase. The change in mean is inconclusive.

## Correct answer: C Difficulty level: 3

36. 

The bar graph to the left summarizes the household size of social worker's client families. Which
statement best describes the relationship between the mean and median household size?

A. The mean is greater than the median, because there are 2 families with many more than $\mathbf{4}$ family members.
B. The median is greater than the mean, because there are more families with more than $\mathbf{4}$ family member than with fewer members.
C. The mean and the median are equal, because there are more than twice as many families with 4 member than with any other number.
D. There is not enough information to compare the mean and the median.

## Correct answer: A

Difficulty level: 3
37.

The time in minutes, rounded to the nearest minute, that runners took to finish a $\mathbf{3}$-mile race is shown in the table to the left. If the mean finish time was 21 minutes, what is the value of $\boldsymbol{r}$ in this table?

| Time in minutes | Number of runners |
| :---: | :---: |
| 18 | 1 |
| 19 | 2 |
| 20 | 3 |
| 21 | 6 |
| 22 | $r$ |
| 23 | 1 |
| 24 | 2 |

A. 1
B. 2
C. 3
D. 6

Correct answer: B
Difficulty level: 4
38.

A student repeatedly tests the solubility of dibutyl phthalate, a chemical used in plastic, in water. The results, in moles of dibutyl phthalate per liter of water are:

$$
5.2 \cdot 10^{-5}, \quad 3 \cdot 10^{-5}, \quad \text { and } \quad 3.5 \cdot 10^{-5}
$$

The student calculates the mean and median of the results, then reads on the safety sheet for the chemical that its solubility is $1.4 \cdot 10^{-4}$ moles per liter of water. How would the mean and median change if the student includes the solubility from the safety sheet in the calculations?
A. They will both decrease, but the mean will decrease more.
B. They will both decrease, but the median will decrease more.
C. They will both increase, but the mean will increase more.
D. They will both increase, but the median will increase more.

## Correct answer: C <br> Difficulty level: 4

39. 

For each of the $\mathbf{5 0}$ largest airlines in the world, its percentage of on-time flights is plotted to the left to the nearest 5 percent. According to the dot plot, which of the following is true?

A. There are an equal number of points to the left of $\mathbf{7 2 . 5}$ as to the right of $\mathbf{7 2 . 5}$, so the median percentage of on-time flights is $\mathbf{7 2 . 5}$.
B. There are an equal number of points to the left of $\mathbf{7 2 . 5}$ as to the right of $\mathbf{7 2 . 5}$, so the mean percentage of on-time flights is $\mathbf{7 2 . 5}$.
C. There is a smaller concentration of points on the left side of the dot plot, so the median percentage of on-time flights is less than the mean.
D. There is a smaller concentration of points on the left side of the dot plot, so the mean percentage of on-time flights is less than the median.

## Correct answer: D Difficulty level: 4

40. 

The dot plot above depicts the heights in inches of players on a professional basketball team. What would happen to the standard deviation of the data set if the lowest and highest heights were removed?


Heights of NBA players in inches
A. It would increase.
B. It would decrease.
C. It would remain the same.
D. There is not enough information to determine the impact on the standard deviation of the data set.
Correct answer: B Difficulty level: 4
41.

A farmer recorded the total fresh yield, in kilograms per hectare $\left(\frac{k g}{h a}\right)$, of several varieties of onion crops. The table at left gives the results. If the farmer tried a new variety, with a $57,930 \frac{\mathrm{~kg}}{\mathrm{ha}}$ yield, how would it affect the median and mean of the crop yields?

| Crop | Yield $\left(\frac{\mathrm{kg}}{\mathrm{ha}}\right)$ |
| :---: | ---: |
| A | 46,400 |
| B | 75,000 |
| C | 75,930 |
| D | 53,130 |
| E | 42,530 |

A. Both the median and the mean will increase.
B. Both the median and the mean will decrease.
C. The median will decrease, but the mean will increase.
D. The median will increase, but the mean will decrease.

Correct answer: D
Difficulty level: 4
42.

Land surveyors visited a small fishing village and divided the land into plots, each $\mathbf{1 2 0}$ square meters in area. They counted the number of dwellings on each plot and recorded their data in the bar graph to the left. Due to people moving away from the village, some residents are now combining dwellings together in order to create larger ones. If this is the only change being made to the data, then which of the following must be true when the land is surveyed again?

A. The mean number of dwellings will decrease.
B. The median number of dwellings will decrease.
C. The range of the number of dwellings will increase.
D. The variance of the number of dwellings will increase.

## Correct answer: A <br> Difficulty level: 4

43. 

Judah, a marketing consultant, tracked how many times his customers asked a question during his sales calls over a one month period. Based on the results shown in the distribution above, what was the median number of questions asked?

A. 4
B. 4.5
C. 5
D. 5.5

## Correct answer: B

Difficulty level: 4
44.

A class used catapults to launch 2 kinds of gummy candies. The dot plots at left record the distances the gummy candies travelled, in inches. Which statement best compares the standard deviations and the means of the distances travelled of the $\mathbf{2}$ kinds of candies?

A. The worm gummy distances have a greater standard deviation and mean than the fish gummy dis
B. The worm gummy distances have a greater standard deviation, but a lower mean than the fish gummy distances.
C. The fish gummy distances have a greater standard deviation and mean than the worm gummy distances.
D. The fish gummy distances have a greater standard deviation, but a lower mean than the worm gummy distances.
45.

An employer wanted to compare the commute times between $\mathbf{1}^{\text {st }}$ and $\mathbf{2}^{\text {nd }}$ shift employees. Both shifts had a mean commute of 17 minutes. The histograms to the left summarize the average commute times of the employees. Which of the following statements best compares the standard deviations of the shifts?

A. The standard deviations are equal.
B. The standard deviation for the $1^{\text {st }}$ shift employees is greater.
C. The standard deviation for the $2^{\text {nd }}$ shift employees is greater.
D. Histograms do not provide enough information to compare standard deviations.

Correct answer: C
Difficulty level: 4
46.

The histograms to the left show the test results of two different $11^{\text {th }}$ grade history classes on the same exam. Which statement best compares the standard deviations of the two data sets?

A. he standard deviation of the scores from class $\mathbf{A}$ is greater than the standard deviation of the scores from class B.
B. The standard deviation of the scores from class $\mathbf{B}$ is greater than the standard deviation of the scores from class $\mathbf{A}$.
C. The standard deviation of the scores from class $\mathbf{A}$ is equal to the standard deviation of the scores from class B.
D. There is not enough information to compare the two standard deviations.

Correct answer: B
Difficulty level: 4
47.

A candidate in a local election analyzed the voter data for 7 of the towns where she was on the ballot. If the median number of votes that she received from the 7 towns was 421 , then which statement must be true about this election?
A. The total number of votes the candidate received in all 7 towns was 2947.
B. The total number of votes the candidate received in each of the 7 towns was 60 .
C. The candidate received at least 421 votes in at least 4 of the 7 towns.
D. The candidate received exactly 421 votes in 2 of the 7 towns.

## Correct answer: C

Difficulty level: 4
48.

In San Francisco, the number of employees in each occupation was recorded and rounded to the nearest 5 thousand. The results are displayed in the dot plot above. If each occupation is split into two separate occupations of equal number of employees, then which of the following occurs?

$0 \quad 5101520253035404550556065707580859095100$
Number of employees in occupation (in thousands)
A. Only the mean number of employees decreases.
B. Only the mean and median number of employees decreases.
C. Only the mean, median, and range of the number of employees decreases.
D. The mean, median, range, and standard deviation of the number of employees decreases.

Correct answer: D Difficulty level: 4
49.

Bally tracked the number of living organisms she found at different depths in a pond near her home, as shown in the histogram to the left. What is the range of depths at which Bally found living organisms?

A. 1
B. 4
C. 5
D. 10

## Correct answer: B Difficulty level: 4

50. 

The number of runs scored by the Beavers little league baseball team in their previous six games is shown above. If the Beavers score 7 runs in the seventh game, which of the following statements must be true?

Runs Scored

| Game 1 | Game 2 | Game 3 | Game 4 | Game 5 | Game 6 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 5 | 9 | 0 | 5 | 0 | 7 |

A. The mean and median number of runs both increase.
B. The mean and median number of runs both remain the same.
C. The mean number of runs increases while the median number of runs stays the same.
D. The mean number of runs stays the same while the median number of runs increases.

## Correct answer: C

Difficulty level: 4
51.

The four dot plots below show the student height distributions of four different $11^{\text {th }}$ grade math classes. In which of the data sets is the mean greater than the median?


Class A Student Height Distribution in Inches



## Correct answer: D Difficulty level: 4

52. 

A survey in Boston measures the highest grade level that each person of age $\mathbf{3 0}$ or over has reached. Grades 13-16represent college, and grades $17-20$ represent advanced degrees. The number of people at each grade level is expressed as a percentage of the total population, as shown to the left. A new tutoring program will cause some people who did not reach grade $\mathbf{1 6}$ to reach grade16. If this is the only change that occurs in the data, then which of the following must be true?

A. The mean highest grade level reached will increase.
B. The mean highest grade level reached will decrease.
C. The median highest grade level reached will increase.
D. The median highest grade level reached will decrease.

## Correct answer: A

Difficulty level: 4
53.

The histogram at left summarizes the Flesch grade equivalents (a readability statistic) for the Newbery award winning books from1922-1993. If the book with the highest Flesch grade equivalent fit in the $\mathbf{6}$ to $\mathbf{6 . 9}$ interval instead, what effect would that likely have on the median and the standard deviation of the Flesch grade equivalents?

A. The interval containing the median and the standard deviation would decrease.
B. The interval containing the median would decrease, but the standard deviation would increase.
C. The median would remain in the same interval, but the standard deviation would decrease.
D. The median would remain in the same interval, but the standard deviation would increase.

## Correct answer: C

Difficulty level: 4
54.

The table to the left partially records the numbers of pairs of socks manufactured by a company each quarter. If the median of all $\mathbf{9}$ quarters is $\mathbf{1 1 , 8 3 0}$, and the range is the same with and without quarter $\mathbf{I}$, which of the following could be the number of pairs of socks manufactured in quarter $\mathbf{I}$ ?

| Quarter | Pairs of socks manufactured |
| :---: | ---: |
| A | 10,765 |
| B | 12,268 |
| C | 12,729 |
| D | 11,568 |
| E | 11,830 |
| F | 13,480 |
| G | 11,345 |
| H | 15,072 |
| I | $?$ |

A. 8,962
B. 10,816
C. 12,739
D. 15,511

Correct answer: B
Difficulty level: 4
55.

The area in thousands of square kilometers of $\mathbf{1 9}$ countries in East and Southeast Asia are shown in the dot plot at left. Each value is rounded to the nearest $\mathbf{2 5 0}$ thousand square kilometers. China, which has an area of $\mathbf{9 , 5 9 7}$ thousand square kilometers, was excluded from the data. If China were included, then which of the following changes would NOT occur?

A. The mean area would increase.
B. The median area would increase.
C. The range of the areas would increase.
D. The standard deviation of the areas would increase.

## Correct answer: B Difficulty level: 4

56. 

The change in students' pulse rates after an activity was measured in beats per minute. In one group of students, the activity was running. In the other group of students, the activity was sitting. Both groups had roughly the same number of students. For the running group, the measurements were rounded to the nearest 5 beats per minute. Which of the following statements correctly compares the variance of the change in pulse rate of both groups?

A. The variance of the running group is greater.
B. The variance of the sitting group is greater.
C. The variances of the groups are within 55 beats per minute of each other.
D. There is not enough information to compare the variances of the two groups.

## Correct answer: A

Difficulty level: 4
57.

A geologist used beryllium -10 dating on several samples of rock at a site to estimate how long the rock had been exposed at the surface. Which of the following best compares the median to the mean of the data?

## Years of exposure

## H1HHH1HH

$\begin{array}{llllllll}20 & 22 & 24 & 26 & 28 & 30 & 32 & 34\end{array}$
A. The median and the mean are approximately equal, because the distribution is symmetrical.
B. The median is lower than the mean because 2 of the samples are several years older than the rest.
C. The median is higher than the mean because many more of the samples had $\mathbf{2 5}$ years or less
D. There is not enough information to compare the median and the mean.

## Correct answer: B

Difficulty level: 4
58.

The time in minutes, rounded to the nearest minute, that runners took to finish a 3-mile race is shown in the table to the left. If the mean finish time was 21 minutes, what is the value of $\boldsymbol{r}$ in this table?

Time in minutes Number of rumers

| 18 | 1 |
| :--- | :--- |
| 19 | 2 |
| 20 | 3 |
| 21 | 6 |
| 22 | $r$ |
| 23 | 1 |
| 24 | 2 |

A. 1
B. 2
C. 3
D. 6

Correct answer: B Difficulty level: 4
59.

## Data collection and conclusions

## 1.

The graph above shows the results of a controlled experiment designed by a scientist to determine the effect of magnetic field strength on the growth of sunflower plants. $\mathbf{5 0 0}$ young sunflower plants were randomly assigned to the control or experimental group. In the control group, the scientist grew 250 sunflower plants under normal local geo-magnetic field conditions(30 microteslas). In the experimental group, the scientist grew 250 sunflower plants identically except under a lower geomagnetic field ( $\mathbf{2 0}$ microteslas). Based on the results of this experiment, which conclusion is NOT valid?

A. Sunflower plants grown under lower magnetic field conditions were more likely to weigh more than sunflower plants grown under normal magnetic field conditions.
B. There is evidence of an association between the strength of magnetic field and height in sunflower plants.
C. Sunflower plants grown under lower magnetic field conditions were more likely to be taller than sunflower plants grown under normal magnetic field conditions.
D. Members of the control group were more likely to grow to less than $\mathbf{1 0 0}$ inches than members of the experimental group.

## Correct answer: A Difficulty level: 2

2. 

A researcher wants to conduct a survey to gauge United States (U.S.) voters' opinions about the U.S. Congress. Which of the following should NOT be a component of this survey?
A. The researcher collects data from the survey takers.
B. The researcher analyzes data from the survey takers.
C. The researcher distributes the survey to $\mathbf{1 0 , 0 0 0}$ randomly selected U.S. citizens aged 18 and
older.
D. The researcher distributes the survey to $\mathbf{1 0 , 0 0 0}$ residents of a Washington D.C. neighborhood.

## Correct answer: D Difficulty level: 2

## 3.

A scientist wants to collect data about the effects of gravity on the growth of soybean plants. To test her hypothesis that soybeans grow better in a zero-gravity setting, she randomly assigns the plants into one of two groups. The first group is grown in typical soybean growing conditions in a greenhouse on earth, and the second group is grown in a zero-gravity, yet otherwise identical greenhouse in a space station. Which of the following is the best description of the research design for this study?
A. Controlled experiment
B. Observational study
C. Sample Survey
D. None of the above

Correct answer: A

## Difficulty level: 2

4. 

A researcher representing a city government wants to measure public opinion about recycling by asking 1,000 randomly selected residents a series of questions on the subject. Which of the following is the best description of the research design for this study?
A. Observational study
B. Sample Survey
C. Controlled experiment
D. None of the above

Correct answer: B
Difficulty level: 2
5.

In order to determine whether children who have just watched cartoons will perform better on cognitive tasks than children who have not just watched cartoons, researchers randomly divided 60 preschoolers into three groups. For nine minutes, one group watched a rapid-paced cartoon, one group watched a slower-paced educational program, and one group colored. They then administered standardized tests to determine the immediate impact of the children's previous nine minutes of activity. Which of the following is the best description of this type of research design?
A. An observational study, a study in which investigators observe subjects and measure variables of interest without assigning treatments to the subjects.
B. A controlled experiment, a study in which an investigator separates subjects into a control group that does not receive a treatment and an experimental group that receives a treatment, and then observes the effect of the treatment on the experimental group.
C. A sample survey, a study that obtains data from a subset of a population, usually through a questionnaire or interview, in order to estimate population attributes.
D. None of the above

## Correct answer: B <br> Difficulty level: 2

6. 

United States (U.S.) Social Media Usage over Time by Age Group

| Year | Percentage of <br> internet users <br> aged $18-29$ that <br> use social <br> media | Percentage of <br> internet users <br> aged $30-49$ <br> use social <br> mediat | Percentage of <br> internet users <br> aged $50-64$ that <br> use social <br> media | Percentage of <br> internet users <br> aged $65+$ that <br> use social <br> media |
| :--- | :--- | :--- | :--- | :--- |
| 2005 | $9 \%$ | $7 \%$ | $6 \%$ | $0 \%$ |
| 2006 | $50 \%$ | $8 \%$ | $4 \%$ | $1 \%$ |
| 2008 | $70 \%$ | $30 \%$ | $11 \%$ | $7 \%$ |
| 2009 | $79 \%$ | $48 \%$ | $28 \%$ | $13 \%$ |
| 2010 | $86 \%$ | $62 \%$ | $47 \%$ | $26 \%$ |
| 2011 | $85 \%$ | $67 \%$ | $49 \%$ | $30 \%$ |
| 2012 | $92 \%$ | $73 \%$ | $57 \%$ | $36 \%$ |
| 2013 | $90 \%$ | $78 \%$ | $65 \%$ | $46 \%$ |

The table above shows the results of an observational study designed to observe the social media habits of different age groups of internet users in the U.S. between 2005 and 2013. Based on the results of this study, which of the following conclusions are valid?

I: In each year of the study, U.S. internet users aged 18-29 were more likely to use social media than any other age group in the study.

II: Over the course of the study, there was growth in the percentage of U.S. internet users that use social media across all of the age groups observed.

III: The rate of social media use by U.S. internet users will continue to rise in the future.

IV: Social media was more likely to be used by a U.S. internet user aged 30-49 in 2013 than it was by a U.S. internet user aged 30-49 in 2005.
A. I only
B. I and IV
C. I, II, and IV
D. I, II, III, and IV

Correct answer: C Difficulty level: 3
7.


The table above shows the results of a controlled experiment designed to determine the effect that adding sodium chloride to water has on the boiling point of water at sea level. Based on the results of this experiment, what conclusion is NOT valid when up to three tablespoons of sodium chloride are added to one quart of water?
A. The more sodium chloride that is added to boiling water, the higher the water's boiling temperature becomes.
B. The more sodium chloride that is added to water, the longer the water will take to boil.
C. There is an association between adding sodium chloride to water and an increase in the boiling temperature of water.
D. There is a linear relationship between sodium chloride added to water and the water's boiling temperature.

## Correct answer: B Difficulty level: 3

## 8.

Louis Pasteur conducted a famous experiment that addressed the question: "Can microorganisms generate spontaneously?" To replicate the experiment, in the control group, purify water in closed flasks by boiling them, and then let the water sit in the closed flasks at room temperature for a predetermined period of time. In the experimental group, purify water in identical closed flasks by boiling them. However, before letting the experimental group sit at room temperature for the predetermined period of time, break the top stem of these flasks to expose the water to outside elements. After the predetermined period of time, if no microorganisms are observed in the control flasks and several thousand microorganisms are observed in each experimental flask, which of the following conclusions are valid?
I: When closed off to outside elements, purified water will not spontaneously generate microorganisms.

II: Exposing water to the elements causes the water to become harmful to humans.

III: Breaking the top stem of the experimental flask allowed the microorganisms to enter the purified water.

IV: Not breaking the stem of the control flask prevented microorganisms from entering the purified water within.
A. III only
B. III and IV
C. I,III, and IV
D. I,II,III, and IV

## Correct answer: C

## Difficulty level: 3

## 9.

A writer for a high school newspaper is conducting a survey to estimate the number of students that will vote for a particular candidate in an upcoming student government election. All students at the high school are eligible to vote in the election, and the writer decides to select a sample of students to take the survey. Which of the following sampling methods is most likely to produce valid results?
A. Survey every fifth student to enter the school library.
B. Survey every fifth student to arrive at school one morning.
C. Survey every fifth senior to arrive at school one morning.
D. Survey every fifth student to enter the school stadium for a football game.

## Correct answer: B <br> Difficulty level: 3

10. 



The graph shown above shows the results of an observational study of corn grain yield, in bushels per acre, versus rate of nitrogen fertilizer solution, in pounds per acre, applied to crops. Based on the results of this study, which conclusion is best supported by the data?
A. Using nitrogen in the soil causes greater grain yield.
B. There is evidence of a linear association between the amount of nitrogen applied to the soil and the grain yield.
C. There is evidence of an association between the amount of nitrogen applied to the soil and the
grain yield, but the association does not appear to be linear.
D. Low levels of nitrogen in the soil leads to poor grain yield.

## Correct answer: C Difficulty level: 3

11. 

The effect of tailgate position on fuel consumption

| Distance <br> traveled <br> (miles) | Gallons of fuel used <br> with the tailgate up | Gallons of fuel used with <br> the tailgate halfway up | Gallons of fuel used <br> with the tailgate down |
| ---: | ---: | ---: | ---: |
| 0 | 0.00 | 0.00 | 0.00 |
| 5 | 0.25 | 0.27 | 0.28 |
| 10 | 0.50 | 0.54 | 0.56 |
| 15 | 0.75 | 0.81 | 0.83 |
| 20 | 1.00 | 1.08 | 1.11 |
| 25 | 1.25 | 1.35 | 1.39 |

The table above shows the results of a controlled experiment designed to determine the effect of tailgate position on the fuel consumption of a pickup truck. Based on the results of this experiment, which conclusion is NOT valid?
A. The truck needed the least fuel to travel a set distance when its tailgate was all the way up.
B. The truck needed the most fuel to travel a set distance when its tailgate was all the way down.
C. There is an association between the truck's tailgate position and the amount of fuel needed to travel a set distance.
D. A truck driver who drives with the tailgate up will spend less money on fuel than when the truck driver drives with the tailgate down.

## Correct answer: D

## Difficulty level: 4

12. 

An ecologist conducted measured the population of brown bears in a North American region and the number of deforested acres in the same region since the year 2000.

The study concluded that as the population of brown bears steadily decreased, the number of deforested acres steadily increased during the same time period. Based on this data, which conclusion is valid?
A. The increase in the number of deforested acres in the North American region since 20002000 caused the decrease in the brown bear population there during the same time period.
B. The decrease in the brown bear population in the North American region since 20002000 caused the increase in the number of deforested acres there during the same time period.
C. There is no evidence of an association between the brown bear population levels in the North American region and the number of deforested acres there in the years since 20002000.
D. There is evidence of an association between the brown bear population levels in the North American region and the number of deforested acres there in the years since 20002000.

## Correct answer: D <br> Difficulty level: 4

13. 

The graph to the left shows the results of a controlled experiment designed to determine how effective a new toothpaste is at preventing cavities. A researcher randomly selected $\mathbf{1 , 0 0 0}$ healthy adults with comparable dental habits and records to participate and randomly assigned participants to either the experimental or control group. In the experimental group, $\mathbf{5 0 0}$ participants were asked to use the new toothpaste for a $\mathbf{6}$ month period. In the control group, the remaining $\mathbf{5 0 0}$ participants were asked to continue using their normal toothpaste during the same $\mathbf{6}$ month period. Based on the results of this experiment, which conclusion is NOT valid?

A. There is an association between the participants brushing their teeth every day and not developing new cavities.
B. There is an association between using the new toothpaste and not developing new cavities.
C. Four hundred members of the experimental group reported no new cavities during the study.
D. Members of the control group were more likely to develop cavities than members of the experimental group.
Correct answer: A Difficulty level: 4
14.


Adapted from "The Role of Deliberate Practice in the Acquisition of Expert Performance," by K.A. Ericsson, R. Th. Krampe, and C. Tesch-Romer, 1993, Psychological Review, 700(3).

In a famous study on the role of practice in the acquisition of expert performance, psychologists compared the amount of time spent on solitary practice, based on diaries and retrospective estimates, for four groups of violinists: professional violinists, the best expert violinists, good expert violinists, and the least accomplished expert violinists (lesser experts). Based on the results of this study, which conclusion is best supported by the data?
A. A violinist who practices about $\mathbf{1 0 , 0 0 0}$ hours by the age of $\mathbf{2 0}$ will become a professional violinist.
B. By the age of $\mathbf{2 0}$, the best experts and professional violinists in the study had practiced more than twice as much as the least accomplished violinists.
C. The least accomplished violinists did not practice as much because they became discouraged.
D. There is no evidence of an association between increased solitary practice before the age of $\mathbf{1 8}$ and level of expertise as a violinist.
Correct answer: B Difficulty level: 4
15.

| City Size | Percent of Canadian <br> Population | Percent of Canadian NHL <br> Players |
| :--- | :--- | :--- |
| $>500,000$ | 33.2 | 15.7 |
| $100,000-499,999$ | 13.3 | 33.2 |
| $30,000-99,999$ | 7.6 | 15.8 |
| $10,000-29,999$ | 7.3 | 10.4 |
| $5,000-9,999$ | 3.4 | 7.7 |
| $2,500-4,999$ | 3.4 | 6.0 |
| $1,000-2,499$ | 3.3 | 6.2 |
| $<1,000$ | 28.5 | 5.1 |

The above table shows the percentages of the Canadian population as well as the percentage of Canadian hockey players in the National Hockey League (NHL) residing in cities of various sizes. Based on the results of this study, which conclusion is best supported by the evidence?
A. There is evidence that players from mid-sized cities $(100,000-499,999)$ are overrepresented in the NHL.
B. Players from very small communities $(<1,000)$ do not have as many opportunities for elite training as players from larger communities.
C. Cities with populations larger than 500,000 are underrepresented in terms of players in the NHL because players in these communities face too much competition.
D. Players in large cities have more opportunities for elite training than do players from smaller cities.

## Correct answer: A Difficulty level: 4

16. 

A local tv news station wants to determine how often and through which medium their viewers check the weather. Which of the following survey methods is most likely to produce valid results?
A. Ask a random sample of their viewers how much they enjoy the weather portion of the local news.
B. Ask a random sample of their viewers whether they own a smartphone.
C. Ask a random sample of members of the local meteorological society whether they watch the local news.
D. Ask a random sample of their viewers how often and when they use various sources to obtain weather information.

## Correct answer: D Difficulty level: 3

17. 

A writer for a high school newspaper is conducting a survey to estimate the number of students that will vote for a particular candidate in an upcoming student government election. All students at the high school are eligible to vote in the election, and the writer decides to select a sample of
students to take the survey. Which of the following sampling methods is most likely to produce valid results?
A. Survey every fifth student to enter the school library.
B. Survey every fifth student to arrive at school one morning.
C. Survey every fifth senior to arrive at school one morning.
D. Survey every fifth student to enter the school stadium for a football game.

## Correct answer: BN <br> Difficulty level: 3

## Volume word problems

## 1.

Cam is making a party hat, shown at left, in the shape of a cone for his birthday. The circumference of the part of his head where the hat will rest is $\mathbf{5 6}$ centimeters ( $\mathbf{c m}$ ). If the height of the hat is $\mathbf{2 5 c m}$, what is the volume of Cam's hat, measured in cubic centimeters $\left(\mathbf{c m}^{\mathbf{3}}\right)$ ? Use $\pi \approx$ 3.14.

A. $233 \mathrm{~cm}^{3}$
B. $2,081 \mathrm{~cm}^{3}$
C. $16,354 \mathrm{~cm}^{3}$
D. $20,515 \mathrm{~cm}^{3}$

Correct answer: B Difficulty level: 2
2.

A set of 3 cylindrical canisters all have diameter 8 centimeters ( cm ). The heights of the canisters are $16 \mathrm{~cm}, 12 \mathrm{~cm}$, and 9 cm , respectively. What is the approximate total volume of the 3 canisters in cubic centimeters $\left(\mathbf{c m}^{3}\right)$ ? Use $\pi \approx 3.14$.
A. $804 \mathrm{~cm}^{3}$
B. $1,055 \mathrm{~cm}^{3}$
C. $1,859 \mathrm{~cm}^{3}$
D. $7,436 \mathrm{~cm}^{3}$

Correct answer: C

## Difficulty level: 2

3. 

A cake pan is in the shape of a right rectangular prism 20 centimeters ( cm ) long by 20 cm wide by 5 cm high. The pan contains 1,000 cubic centimeters $\left(\mathbf{c m}^{3}\right)$ of batter. Approximately how far is the cake batter from the top of the pan?
A. 1 cm
B. 2.5 cm
C. 5 cm
D. 7 cm

Correct answer: B
Difficulty level: 2

## 4.

A household aquarium tank in the shape of a rectangular prism has a base length of 24 inches(in) and a base width of 15 in . The height of the water is 12 in above the base. During cleaning, 900 cubic inches of water is removed. What is the change in the height of the water in inches?


Correct answer: 2.5

## Difficulty level: 2

## 5.

Adolfo wants to send his friend a poster that is 65 centimeters ( cm ) wide and 92 cm long. He will mail the poster in a cylindrical container with a volume of 5,200 cubic centimeters $\left(\mathbf{c m}^{\mathbf{3}}\right)$. Adolfo rolls up the poster so that the width of the poster is aligned with the height of the container. Approximately what is the largest radius the container could have? Use $\pi \approx 3.14$.
A. 4 cm
B. 5 cm
C. 8 cm
D. 25 cm

## Correct answer: B Difficulty level: 2

6. 

A die is created by smoothing the corners of a plastic cube and carving indented pips. The original cube had an edge length of $\mathbf{2}$ centimeters ( $\mathbf{c m}$ ). The volume of the final die is $\mathbf{7 . 5} \mathbf{~ c m}^{\mathbf{3}}$. What is the volume of the waste generated by creating the die from the cube in $\mathbf{c m}^{\mathbf{3}}$ ?


## Correct answer: 0.5

## Difficulty level: 2

7. 

The volume of the triangular prism shown above is $\mathbf{1 6 0}$ cubic centimeters $\left(\mathbf{c m}^{\mathbf{3}}\right)$. What is the vertical height, $\boldsymbol{h}$, in centimeters (cm), of the triangular base of the prism?

A. 5 cm
B. 8 cm
C. 12 cm
D. 40 cm

## Correct answer: B Difficulty level: 2

8. 

Sean has ordered a gift online and was told it will be delivered in a cube-shaped gift box with volume 8,000 cubic centimeters $\left(\mathbf{c m}^{3}\right)$, shown at left. In order to purchase enough wrapping paper to cover the box, he must calculate its surface area. What is the surface area of the box, in square centimeters ( $\mathbf{c m}^{2}$ )?

A. $1,200 \mathrm{~cm}^{2}$
B. $1,600 \mathrm{~cm}^{2}$
C. $2,000 \mathrm{~cm}^{2}$
D. $2,400 \mathrm{~cm}^{2}$

Correct answer: D Difficulty level: 2
9.

A wooden door wedge has the shape of a right triangular prism as shown above. The right triangular faces have a length of $1=10$ centimeters $(\mathrm{cm})$ and a height of $\mathrm{h}=4 \mathrm{~cm}$. The prism has a width of $w=3 \mathrm{~cm}$. What is the volume of the door wedge in cubic centimeters?


## Correct answer: 60

Difficulty level: 2
10.

One of the Great Pyramids of Giza, the pyramid at Khufu shown above, has a square base with sides of length 230 meters (m). The original vertical height of the right pyramid is believed to have been approximately 146.5 m . Due to erosion over several thousand years, the height is now approximately 139 m . Assume that the present figure, shown at left, is still a right pyramid with the same base. Approximately how much did the volume, measured in cubic meters $\left(\mathrm{m}^{3}\right)$, of the pyramid at Khufu decrease since it was built?
A. $575 \mathrm{~m}^{3}$
B. $132,250 \mathrm{~m}^{3}$
C. $2,451,033 \mathrm{~m}^{3}$
D. $2,583,283 \mathrm{~m}^{3}$

## Correct answer: B Difficulty level: 2

11. 

A cylinder and cone have equal volumes and radii of equal length. If the height of the cone is 24 centimeters, then what is the height of the cylinder in centimeters?
$\square$

## Correct answer: 8

## Difficulty level: 2

12. 

A new dictionary in the shape of a rectangular prism will have a thickness of 3 inches (in). The volume of the dictionary will be $216 \mathrm{in}^{3}$. What must be the area of the front cover, a face perpendicular to the thickness, in square inches?


## Correct answer: 72

Difficulty level: 2
13.

A cube of gold with an edge length of 3 inches (in) is melted and reformed into a rectangular prism with a width of 2.5 in and a height of 2 in . If the volume is unchanged during melting, what is the length of the prism of gold in inches?


## Correct answer: 5.4

## Difficulty level: 2

14. 

A top is formed by fusing two identical right circular cones by their bases as shown at left. The
height of the top, $\boldsymbol{h}$, which is the distance between the two cone points, is $\mathbf{6}$ centimeters ( $\mathbf{c m}$ ). The diameter of the circular cone bases, $\boldsymbol{d}$, is also $\mathbf{6} \mathbf{c m}$. What is the volume of the top, in cubic centimeters?
A. $9 \pi$
B. $18 \pi$
C. $36 \pi$
D. $72 \pi$

Correct answer: B Difficulty level: 3
15.

Anya has two different sized cylindrical coffee mugs. The larger mug has an internal height of 15 centimeters ( cm ), and the smaller mug has an internal height of 10 cm . Both mugs have an internal diameter of 8 cm . Which of the following is closest to the difference in cubic centimeters $\left(\mathbf{c m}^{\mathbf{3}}\right)$ between the internal volume of the larger mug and the internal volume of the smaller mug?
A. $63 \mathrm{~cm}^{3}$
B. $251 \mathrm{~cm}^{3}$
C. $754 \mathrm{~cm}^{3}$
D. $1,005 \mathrm{~cm}^{3}$

Correct answer: B Difficulty level: 3
16.

A multi-layer cake is in the shape of a right cylinder. The height of the cake is 20 centimeters ( cm ), and its radius is 10 cm . If each of the cake layers has a volume of approximately 1,250 cubic centimeters, then how many layers does the cake have?


Correct answer: 5

## Difficulty level: 3

17. 

A rectangular prism and cube have equal volumes. The length of the rectangular prism is $\mathbf{1 2}$ centimeters $(\mathbf{c m})$ and its width is $8 \mathbf{c m}$. If each side of the cube is $\mathbf{1 2 \mathbf { c m }}$, then what is the height of the rectangular prism in centimeters?


## Correct answer: 18

## Difficulty level: 3

18. 

A soup manufacturer sells its soup in right cylindrical cans. The cans have a diameter of 6 centimeters $(\mathrm{cm})$ and a height of 10 cm . If the manufacturer fills each can to $90 \%$ capacity with soup, rounded to the nearest cubic centimeter, what is the approximate volume of soup in each can?


Correct answer: 254

Difficulty level: 3
19.

An architect has created a scale drawing for a residential townhouse in the shape of a rectangular prism. In the drawing, the internal width of the townhouse is labeled as 18 feet ( ft ), the internal length as 20 ft , and the internal height as 30 ft . The local building department tells the architect that if built, the building would be too tall according to local zoning laws and that its height must be reduced by $10 \%$. If the architect creates a second scale drawing where the townhouse's height is reduced by $10 \%$, what will be its new proposed internal volume in cubic feet?


Correct answer: 9720
20.

A trough shaped as half of a circular cylinder is being constructed as shown at left. It is able to hold 0.5 cubic meters $\left(\mathrm{m}^{3}\right)$ of water. Additionally, its width, $w$, is 50 centimeters ( cm ). Approximating $\pi$ as 3.14 , what is the length of the trough, $l$, to the nearest tenth of a meter?

A. 1.3
B. 2.5
C. 5.1
D. 10.2

## Correct answer: C

Difficulty level: 3
21.

A cylindrical soda can has a volume of $108 \pi$ cubic centimeters $\left(\mathrm{cm}^{3}\right)$ and a height of 12 cm . What is the surface area of the soda can in square centimeters?
A. $18 \pi$
B. $36 \pi$
C. $72 \pi$
D. $90 \pi$

## Correct answer: D <br> Difficulty level: 3

22. 

The formula for the surface area of a sphere is:

$$
A=4 \pi r^{2}
$$

where $A$ is the surface area and $r$ is the radius. A simplified model of the Earth's crust is a hollow spherical shell with an outer diameter of $8,000 \mathrm{miles}(\mathrm{mi})$ and a thickness of 10 mi . Using the fact that the volume of a shell is approximately equal to its outer surface area times its thickness, what is the approximate volume of the earth's crust in cubic miles according to this model?
A. $64,000,000 \pi$
B. $160,000,000 \pi$
C. $640,000,000 \pi$
D. $2,560,000,000 \pi$

Correct answer: C

## Difficulty level: 3

23. 

A paint can in the shape of a right circular cylinder, shown at left, has a height of 20 centimeters $(\mathrm{cm})$. The circumference of the base of the can is 43.96 cm . To the nearest ten cubic centimeters $\left(\mathrm{cm}^{3}\right)$, what is the approximate volume of the paint can?

A. $2,760 \mathrm{~cm}^{3}$
B. $3,080 \mathrm{~cm}^{3}$
C. $30,340 \mathrm{~cm}^{3}$
D. $121,360 \mathrm{~cm}^{3}$

## Correct answer: B Difficulty level: 3

24. 

A cone and sphere have equal volumes and radii of equal length. If the height of the cone is 36 centimeters, then what is the length of the radius of each shape in centimeters?
$\square$

## Correct answer: 9

Difficulty level: 3
25.

A right triangular prism with an equilateral triangular base is shown above. The height of the right triangular prism is equal to 7 feet ( ft ), and each side of the triangular base is equal to 5 ft . What is the volume of the right triangular prism, rounded to the nearest cubic foot?


## Correct answer: 76

## Difficulty level: 3

26. 

A right triangular prism with a right isosceles triangular base is shown above. The height of the prism is equal to 9 centimeters $(\mathrm{cm})$, and the base of the right isosceles triangle is equal to 8 cm . What is the volume of the prism, rounded to the nearest cubic centimeter?

$\square$

## Correct answer: 144

 Difficulty level: 327. 

A cylinder and sphere have equal volumes and radii of equal length. If the height of the cylinder is 8 centimeters, then what is the length of the radius of each shape in centimeters?

## Correct answer: 6

## Difficulty level: 3

28. 

The roof the the Ericsson Globe in Stockholm is shaped like a hemisphere with a volume of $111,000 \pi$ cubic meters $\left(\mathrm{m}^{3}\right)$. What is the diameter of the roof of the Ericsson Globe in meters?
A. $\sqrt[3]{83,250}$
B. $\sqrt[3]{166,500}$
C. $2 \sqrt[3]{83,250}$
D. $2 \sqrt[3]{166,500}$

Correct answer: D Difficulty level: 3
29.

A building contractor has a pickup truck with a rear storage area in the shape of a rectangular prism. The storage area has a length of 80 inches (in), a width of 60 in , and a height of 44 in . She wants to fill the entire storage area with equal-sized rectangular prism-shaped bricks with lengths of 8 in , widths of 4 in , and heights of 2 in . How many bricks can the contractor fit in the storage area of her truck?


## Correct answer: 3300

## Difficulty level: 3

30. 

An artist has a cylindrical container that is filled with sculpting clay. The container has a radius of 10 centimeters $(\mathrm{cm})$ and a height of 30 cm . The artist removes a piece of clay and sculpts it into a sphere with a radius of 6 cm . If the artist sculpts as many identical spheres as possible with the amount of clay in the container, how many total identical spheres will the artist be able to sculpt? Use $\pi \approx 3.14$.


## Correct answer: 10

Difficulty level: 3
31.

Two large spherical balloons are being inflated for a party. It takes more air to increase the diameter of the larger balloon from 36 centimeters $(\mathrm{cm})$ to 40 cm than to increase the diameter of
the smaller balloon from 26 cm to 30 cm . Approximately how much more air is needed, in cubic centimeters $\left(\mathrm{cm}^{3}\right)$ ? Use $3.14 \pi \approx 3.14$.
A. $990 \mathrm{~cm}^{3}$
B. $4,145 \mathrm{~cm}^{3}$
C. $4,932 \mathrm{~cm}^{3}$
D. $33,158 \mathrm{~cm}^{3}$

## Correct answer: B

## Difficulty level: 4

32. 

The Louvre Pyramid, designed by the architect I. M. Pei, is a landmark in the city of Paris. The right square pyramid has a vertical height of 21.6 meters ( m ) and a square base with side length 35 m . The Inverted Pyramid is a skylight in the shape of an upside-down pyramid located on the ceiling of a mall below the main Pyramid. The Inverted Pyramid has sides of length 16 m and vertical height 7 m . Approximately how much greater is the volume of the Louvre Pyramid than the volume of the Inverted Pyramid, to the nearest cubic meter $\left(\mathrm{m}^{3}\right)$ ?


Correct answer: 8223

## Difficulty level: 4

33. 

A grain silo, shown in the figure at left, consists of a regular cylinder with an internal height of 90 meters (m) and a top hemisphere with an internal diameter of 60 m . If the internal diameters of the hemisphere and the cylinder are equal, which of the following is closest to the internal volume of the grain silo in cubic meters $\left(\mathrm{m}^{3}\right)$ ?


Note: figure not drawn to scale
A. $311,018 \mathrm{~m}^{3}$
B. $367,566 \mathrm{~m}^{3}$
C. $572,555 \mathrm{~m}^{3}$
D. $1,470,265 \mathrm{~m}^{3}$

## Correct answer: A

34. 

The inside of a beaker is shaped like a circular cylinder with a base diameter of 12 centimeters $(\mathrm{cm})$. Water in the beaker is filled to a height of 8 cm above the base. A stainless steel sphere with a diameter of 6 cm submerged in the liquid displaces an equal volume of water. How high above the base of the beaker is the new water level, in centimeters?


## Correct answer: 9

## Difficulty level: 4

35. 

A rubber stopper used for plugging chemical flasks has the shape of a frustum as shown at left. The frustum is 3 centimeters ( cm ) high and was cut from the bottom 3 cm of a cone with a height of 15 cm and a base radius of 1.5 cm . The radius of the top circular face of the rubber stopper is 1.2 cm . What is the volume of the stopper in cubic centimeters $\left(\mathrm{cm}^{3}\right)$ ?

A. $2.25 \pi$
B. $5.4 \pi$
C. $5.49 \pi$
D. $6.3 \pi$

Correct answer: C Difficulty level: 4
36.

An ice cream bombe, shown at left, is made by layering different flavors of ice cream in a bowl that is in the shape of a hemisphere. Assume the bowl is 20 centimeters (cm) in diameter. The first layer of ice cream covers the inside of the bowl and forms a shell 4 cm thick. Approximately what volume of ice cream, in cubic centimeters $\left(\mathrm{cm}^{3}\right)$, is needed to fill the rest of the bowl? Use $\pi \approx 3.14$.

A. $452 \mathrm{~cm}^{3}$
B. $904 \mathrm{~cm}^{3}$
C. $1,072 \mathrm{~cm}^{3}$
D. $8,574 \mathrm{~cm}^{3}$

Correct answer: A
Difficulty level: 4
37.

A candy box, shown at left, is in the shape of a right triangular prism whose base is an equilateral triangle of side length $\boldsymbol{s}$. For shipping and packing purposes, the length, $\boldsymbol{l}$, of the box must be $\mathbf{2 0}$ centimeters ( $\mathbf{c m}$ ), and the volume of the box must be $\mathbf{1 0 0}$ cubic centimeters $\left(\mathrm{cm}^{3}\right)$. What is the side length, $\boldsymbol{s}$, of the base of the box, rounded to the nearest tenth of a centimeter? The volume $\boldsymbol{V}$ of a right triangular prism of length $\boldsymbol{l}$ and base area $\boldsymbol{A}$ is $\boldsymbol{V}=\boldsymbol{A l}$.

A. 2.4 cm
B. 3.4 cm
C. 4.8 cm
D. 11.5 cm

## Correct answer: B

Difficulty level: 4
38.

The shape of a solid wire can be approximated by a long cylinder with a base diameter, or wire thickness, of 1 centimeter. The wire is wound ten times into a circular loop of diameter 1 meter. What is the total volume of the wire in cubic centimeters?
A. $25 \pi^{2}$
B. $250 \pi^{2}$
C. $500 \pi^{2}$
D. $1,000 \pi^{2}$

## Correct answer: B Difficulty level: 4

39. 

A large spherical balloon inflated with air is 60 centimeters (cm) in diameter. Approximately what volume of air, to the nearest cubic centimeter $\left(\mathrm{cm}^{3}\right)$, is needed to increase the diameter of the balloon by 6 cm ? Use $\pi \approx 3.14$.


Correct answer: 37416
Difficulty level: 4
40.

The salt piles in a particular salt mine are shaped like circular cones. They have the property that their base diameter is twice the height of the pile. Assuming a pile is created from 1,000 cubic meters of salt, what is the circumference of the circular base in meters?
A. $10 \sqrt[3]{3 \pi^{2}}$
B. $20 \sqrt[3]{3 \pi^{2}}$
C. $30 \sqrt[3]{3 \pi^{2}}$
D. $40 \sqrt[3]{3 \pi^{2}}$

Correct answer: B Difficulty level: 4
41.

An oxygen tank is shaped like a cylinder with two hemispheres attached to the cylinder bases as shown at left. The diameter of the cylinder and hemispheres is 6 inches (in). The height of the entire tank is 16 in . What is the volume of the oxygen tank in cubic inches?

A. $126 \pi$
B. $144 \pi$
C. $180 \pi$
D. $504 \pi$

Correct answer: A
Difficulty level: 4
42.

A pyramid is formed from six identical steel beams of length $l$ such that its base forms an equilateral triangle. The height $h$ is equal to $\frac{\sqrt{6}}{3} l$. What is the volume of the pyramid in terms of $l$ ?

A. $\frac{\sqrt{2}}{12} l^{3}$
B. $\frac{\sqrt{3}}{12} l^{3}$
C. $\frac{\sqrt{2}}{4} l^{3}$
D. $\frac{\sqrt{3}}{4} l^{3}$

## Correct answer: A

## Difficulty level: 4

43. 

A metal pipe has the shape of a hollow cylinder as shown at left. The length of the pipe is $l=30$ centimeters $(\mathrm{cm})$, the thickness of the pipe is $t=1 \mathrm{~cm}$, and the internal diameter is $d=4 \mathrm{~cm}$. What is the volume of the pipe material in cubic centimeters?

A. $120 \pi$
B. $150 \pi$
C. $270 \pi$
D. $600 \pi$

Correct answer: B
Difficulty level: 4
44.

A regulation FIFA soccer ball is modeled after the Buckyball, a truncated icosahedron that was introduced by Buckminster Fuller. Due to air pressure, the inflated ball assumes the shape of an almost perfect sphere. A regulation soccer ball has a circumference of 70 centimeters (cm). What is the approximate volume of the soccer ball in cubic centimeters $\left(\mathrm{cm}^{3}\right)$ ? Use $\pi \approx 3.14$ and round the answer to the nearest whole number.

A. $5,792 \mathrm{~cm}^{3}$
B. $46,338 \mathrm{~cm}^{3}$
C. $179,594 \mathrm{~cm}^{3}$
D. $1,436,755 \mathrm{~cm}^{3}$

Correct answer: A Difficulty level: 4
45.

A "conical bottom tank," shown at left, is a large container used in water purification plants. The tank consists of a cylinder with a cone at the bottom for drainage. A conical bottom tank has a cylinder of height 175 centimeters and diameter 120 centimeters. The cone at the bottom has height 50 centimeters. What is the volume of the conical bottom tank, to the nearest cubic centimeter? Use $\pi \approx 3.14$.

A. 1,789,800 cubic centimeters
B. 188,400 cubic centimeters
C. $1,978,200$ cubic centimeters
D. $2,166,600$ cubic centimeters

## Correct answer: D

Difficulty level: 4
46.

A gemstone, shown at left, is being carved in the shape of a right square pyramid from a hemispherical stone with diameter 40 millimeters ( mm ). The square base of the pyramid will be carved from the base of the hemisphere. The height of the pyramid will coincide with the radius of the hemisphere. What is the volume, in cubic millimeters $\left(\mathrm{mm}^{3}\right)$, of the right square pyramid that can be carved from the hemisphere, as shown below?

A. $2,667 \mathrm{~mm}^{3}$
B. $5,333 \mathrm{~mm}^{3}$
C. $10,667 \mathrm{~mm}^{3}$
D. $16,746 \mathrm{~mm}^{3}$

Correct answer: B
Difficulty level: 4

## Right triangle word problems

1. In a mall, a person rides down an escalator, turns directly left at the base, and walks 16 feet $(f t)$ to a kiosk. The escalator has a vertical rise of $18 f t$ and a horizontal run of $24 f t$. If the person could have traveled in a straight line from the top of the escalator to the kiosk, what would the distance be, in feet?
A. 24 ft
B. 30 ft
C. 34 ft
D. 46 ft

Correct Answer: C Difficulty Level: 3
2.


A contractor must build a wheelchair ramp with a recommended $8^{\circ}$ angle of elevation above the horizontal, as shown above. If the elevation from the sidewalk to the bottom of the door is 3.8 feet ( ft ), how many feet from the door must the ramp begin? (Round your answer to the nearest hundredth of a foot.)
$\square$
Correct Answer: 27.04 Difficulty Level: 3
3.

Caleb is
designing a conveyor belt that has

to move
16 meters
manufactured products up an incline, as shown above. To avoid products sliding or toppling, he has determined an ideal angle above the horizontal of 0.19 radians. What distance, $d$, in meters, will the product be conveyed using Caleb's design?
(Round your answer to the nearest tenth of a meter.)
$\square$

Correct Answer: 16.3 Difficulty Level: 3
4.


The approximate height and base diameter of a conical metal valve plug are shown in the diagram above in centimeters (cm). What is the distance, $d$, in centimeters, from the vertex to the outer edge of the circular base? (Round your answer to the nearest tenth of a centimeter.)
$\square$

Correct Answer: $4.8 \quad$ Difficulty Level: 3
5. On a cloudy night, Madhu, an aviation meteorologist, places a bright light on the ground to shine up at the clouds above, and then he moves to a point exactly 50 feet ( ft ) away from the light. He then measures the angle of inclination to the spot of light on the base of the clouds above, as shown in the figure. If Madhu measures the angle of inclination to be $36.5^{\circ}$ at a height of 4 ft above the ground,
what is the height of the cloud base above the ground, $h$, to the nearest foot?



Feet

## Correct Answer: 41

Difficulty Level: 3
6. A player at point $A$ passes a ball to a player at point $B$. What is the distance, in yards, between point $A$ and point $B$ ? (Round your answer to the nearest tenth of a yard.)

$\square$

Correct Answer: 45.5 Difficulty Level: 2
7. Wanahton's rectangular baking sheet is $9 \frac{1}{2}$ inches (in) by 13 in. To the nearest inch,
what is the longest breadstick Wanahton could bake on his baking sheet?
A. 13in
B. 14 in
C. 124in
D. 259 in

Correct Answer: B $\quad$ Difficulty Level: 2
8. Due to weather, a barge captain decides to reach her destination in two legs: one due north and one due west. On a direct route, her destination is about 1,830 (mi) away; see the figure above. If after traveling 605 mi due north the captain determines it is time to head due west, how many more miles are left in the trip? (Round your answer to the nearest mile.)

$\square$

Correct Answer: 1727 Difficulty Level: 2
9. Abby is buying a widescreen TV that she will hang on the wall between two windows. The windows are 36 inches apart, and wide screen TVs are approximately twice as wide as they are tall. Of the following, which is the longest that the diagonal of a widescreen TV can measure and still fit between the windows?
A. 32 inches
B. 42 inches
C. 55 inches
D. 60 inches

Correct Answer: A Difficulty Level: 2
10. Bilal was assembling a set of bunkbeds and wanted to make sure the support posts were perpendicular to the floor. He measured that the posts were 165 centimeters tall and 220 cm apart. How long should the diagonal measurement be if the support posts are perpendicular to the floor?
A. 72 cm
B. 130 cm
C. 275 cm
D. 385 cm

Correct Answer: C Difficulty Level: 2
11.


Note: Figure not drawn to scale.

The floor inside a bathtub slopes down at a $1.2^{\circ}$ angle toward the drain. The horizontal distance from the far end of the bathtub floor to the drain is 5 feet. What is the total distance the water travels from the far end of the bathtub floor to the drain?

Note: $\sin \left(1.2^{\circ}\right) \approx 0.02094$ and $\cos \left(1.2^{\circ}\right) \approx 0.99978$.
A. 1.26 inches
B. 60.01 inches
C. 165.58 inches
D. 238.75 inches

Correct Answer: B Difficulty Level: 2
12. Using coordinate locations, Colonel Broudin determines his destination to be exactly 432 miles (mi) east and 84 mi north of his ship. In order to make a direct line to his destination, Colonel Broudin must calculate $\theta$ o, as shown above. What is the value of $\theta$, to the nearest tenth of a degree?

$\square$
Correct Answer: 11
Difficulty Level: 2
13. Saul's plane is 6 miles (mi) from the airport runway when he begins his descent from 14,000feet (ft): see the figure above. There are 5,280 feet in 11 mile. How far, in miles, does the plane actually travel in air during its descent? (Round your answer to the nearest mile)

$\square$

Correct Answer: 7

Difficulty Level: 2
14. Li Wei usually gets to work by walking 1.3 miles north on 12 th Street and then turning right $90^{\circ}$ and walking east on Azalia Street for 3.3 miles. His friend mentions that Li Wei could take Washington Street instead, which goes directly from his apartment to his workplace, in a straight line. Approximately how much shorter, in miles, is this route compared to Li Wei's usual walking route? (Round your answer to the nearest tenth of a mile.)
$\square$

Correct Answer: 1.1 Difficulty Level: 2
15. Finn is drafting plans for a staircase that will go from the sidewalk to the doorway of a historic building 84 feet ( ft ) above. He measures the length of a string
stretched from the sidewalk to the door and finds it to be 123 ft , as shown at left. What angle $\theta$, above the horizontal, should be used to build this staircase? (Round your answer to the nearest hundredth of a radian.)


Correct Answer: 0.75
Difficulty Level: 2
16. A forest ranger wants to determine the height of a redwood tree. Standing 145 meters (m) away from the tree, the ranger measures angles of inclination and declination to the tree's top and base, respectively, as shown to the left. Which of the following is closest to the height, $h$, of the tree?

A. 58 meters
B. 59 meters
C. 60 meters
D. 62 meters
17. A player at point $A$ passes a ball to a player at point $B$. What is the distance, in yards, between point $A$ and point $B$ ? (Round your answer to the nearest tenth of a yard.)

$\square$

Correct Answer: 45.5
Difficulty Level: 2
18. A tent forms an equilateral triangular prism, with both triangular faces exposed. The triangular face is 196 centimeters (cm) wide, and the tent is 250 cm long. To the nearest centimeter, what is the height of the tent?
A. 98 cm
B. 170 cm
C. 217 cm
D. 339 cm

Correct Answer: B Difficulty Level: 3
19. A farmer plans to install solar collection panels to provide winter heating for the livestock. The most efficient panel angle for winter heating in the farm's region is $60^{\circ}$ relative to ground level. If an individual panel is 67 inches (in) long and installed on the ground according to these instructions, what is the height of the upper edge above the ground?
A. $33.5 \sqrt{3}$ in
B. $33.5 \sqrt{2} \mathrm{in}$
C. 33.5 in
D. $\frac{134 \sqrt{3}}{3}$ in
20. Tanya is building a swingset for her yard, with the measurements shown above. Tanya adds a brace parallel to the ground. If the lower edge of the brace is 1.4 meters ( m ) above the ground, about what is the width, $w$, in inches, of the brace?

A. 1.6 m
B. 1.7 m
C. 2.1 m
D. 2.4 m

Correct Answer: D Difficulty Level: 3
21. A plumber slopes a drain pipe $\frac{3}{4}$ inch diagonally downward per foot of horizontal distance. The pipe extends 45 feet horizontally. To the nearest inch, what is the length of the pipe?
A. 34 in
B. 56 in
C. 541in
D. 6,493 in

Correct Answer: C Difficulty Level: 3
22. A stained glass box has a hinged lid with a chain to keep the lid from opening too far and knocking the box over. The diagram above represents the side view of the box. About what is the length of chain needed to allow the lid to open $120^{\circ}$ ?

A. $2 \frac{1}{2}$ in
B. $2 \frac{7}{8}$ in
C. $4 \frac{1}{3}$ in
D. $8 \frac{2}{3} \mathrm{in}$
Correct Answer: D
Difficulty Level: 3
23. A spiral staircase makes 4 full turns as it climbs 20 feet ( ft ), as represented in the figure above. The outer railing is a constant distance of 2 ft from the midline of the staircase. About what is the length of the railing?


Correct Answer: C
A. 32 ft
B. 50 ft
C. 54 ft
D. 80 ft
24. According to some reconstructions, the Sneferu pyramid, also called the bent pyramid, had the measurements shown above. Segments that appear parallel are parallel. Based on those measurements, what was the height of the pyramid to the nearest cubit?

Note: $\cos (44) \approx 0.72, \tan (44) \approx 0.97, \cos (54) \approx 0.59$ and $\tan (54) \approx 1.38$.


Correct Answer: 202
Difficulty Level: 4
25. The figure above shows the top view of a wedding cake where each layer is a square-based prism. The corners of each square are placed at the midpoint between the corners of the next largest square. What is the length, $x$, to the nearest
inch (in) of each side of the smallest square?

A. 3 in
B. 6 in
C. 9 in
D. 13 in

Correct Answer: B
Difficulty Level: 4
26. Lamp shade dimensions are typically in the form diameter $\times$ bottom diameter $\times$ slant height. For a lampshade with the measurements in the figure above, to the nearest tenth of an inch, what is the
vertical height of the lampshade?

$\square$

Correct Answer: 13
Difficulty Level: 4
27. The breakover angle is the supplement to the maximum angle of the ground under a vehicle that will not touch its undercarriage. In the figure above, the angled ground is centered between the wheels, with a breakover angle of $23^{\circ}$. To the nearest inch, what is the height, $h$, of the undercarriage above where the wheels touch the ground?

Note: $\cos (11.5) \approx 0.98$ and $\tan (11.5) \approx 0.20$.


Correct Answer: 10

## Difficulty Level: 4

28. An architect is adding a south-facing room to a house. The residents do not want the sun to shine through the window at the peak of summer, when the sun shines at a $73.5^{\circ}$ angle relative to the ground on that side of the house. The window is 1.8 meters long and reaches the ceiling of the room, as shown in the figure to the left. The architect plans a roof overhang parallel to the ground. How wide does
the overhang need to be to block the sun at that angle?
Note: $\sin (73.5) \approx 0.96, \cos (73.5) \approx 0.28, \tan (73.5) \approx 3.38$.

A. 0.51 m
B. 0.53 m
C. 1.27 m
D. 1.73 m

Correct
Answer:
B
Difficulty Level: 3

## 29. Note: Figure not drawn to scale.

When a bicycle turns, its front and rear wheels follow circular paths that have the same center. The turning radius, $r$, for a bicycle depends on the width of the wheelbase and the angle the front wheel can safely turn, as shown in the figure above. What is the turning radius for a bicycle with a 45 inch (in) wheelbase with the front
wheel turned $10^{\circ}$ ?

Note: $\sin (10 \circ) \approx 0.174, \cos (10 \circ) \approx 0.985$, and $\tan (10 \circ) \approx 0.176$.

A. 10 in
B. 14 in
C. 255 in
D. 259 in
30. The diagram above gives the measurements for a side view of a buffet counter with a sneeze guard. What is the approximate distance, $d$ (shown by the dotted line), needed to reach from the sneeze guard to the lower rear corner of the food well?

A. 24 in
B. 28 in
C. 30in
D. 31 in

Correct Answer: C Difficulty Level: 3
31. A plane flies approximately $30^{\circ}$ north of east for 12 kilometers (km)and then continues for the next 31 km at approximately $60^{\circ}$ north of east, as shown at left. What distance, $d$, in kilometers does the plane end up from its original location? (Round your answer to the nearest kilometer.)


Correct Answer: 42
Difficulty Level: 3
32. The dotted line in the ramp shown above is the shortest, but steepest, distance, in feet ( ft ), up the ramp. The dashed line is the longest distance in a straight line up the ramp, but has the least steep slope. To the nearest tenth of a foot, how much longer is the distance with the least slope than the distance with the greatest slope?

$\square$

Correct Answer: $\frac{13}{10}$
Difficulty Level: 3
33. A ladder is leaning against a wall. The top of the ladder is 9 feet ( ft ) above the ground. If the bottom of the ladder is moved 3 ft farther from the wall, the ladder will be lying flat on the ground. How long is the ladder, in feet?


Correct Answer: 15
Difficulty Level: 3
34. In a mall, a person rides down an escalator, turns directly left at the base, and walks 16 feet (ft)to a kiosk. The escalator has a vertical rise of 18 ft and a horizontal run of 24 ft . If the person could have traveled in a straight line from the top of the escalator to the kiosk, what would the distance be, in feet?
A. 24 ft
B. 30 ft
C. 34 ft
D. 46 ft

Correct Answer: C
Difficulty Level: 3
35. Kapil wraps a ribbon diagonally around a cylindrically shaped package, so that it make 3 full turns, then tapes it at each end. The package has a height of 18 centimeters ( cm ), and the ribbon is at a constant $30^{\circ}$ angle relative to the lower edge of the cylinder. About how long does Kapil's ribbon need to be?
A. 10 cm
B. 12 cm
C. 31 cm
D. 36 cm
36. The obelisk in the diagram above is composed of a right square-based pyramid and a truncated right square-based pyramid. The diagram gives the lengths of the
 edges in centimeters (cm). What is the height of the obelisk?
A. $1,019 \mathrm{~cm}$
B. $1,089 \mathrm{~cm}$
C. $1,105 \mathrm{~cm}$
D. $1,120 \mathrm{~cm}$

Correct Answer: B
Difficulty Level: 4
37. A quilter fashions the design shown above of inscribed squares. The corners of each square are $\frac{1}{3}$ of the distance between the corners of the next largest square. What is the length, $x$, to the nearest centimeter (cm), of each side of the smallest square?



Correct Answer: 12

Difficulty Level: 4
38. The far edge of the head of the flashlight is 5.3 inches (in) from the wall, as shown in the figure above. What is the approximate diameter $d$, in inches, of the circle of light cast on the wall?

Note: $\cos (165) \approx-0.97$ and $\sin (165) \approx 0.26$

A. 1.42 in
B. 2.42in
C. 2.84in
D. 3.84in

Correct Answer: D
Difficulty Level: 4
39. The figure above shows the measurements for the pavement in a park meeting space. The shortest section has a base of 3 meters (m). Each of the 18 sections of pavement is a right triangle with a base equal to the length of the previous hypotenuse and a height of 2 m . What is the length, $\ell$, of the hypotenuse of the longest section?

A. 9 m
B. 39 m
C. $18 \sqrt{13} \mathrm{~m}$
D. 81 m

## Correct Answer: A <br> Difficulty Level: 4

40. The screen resolution of a certain cell phone display is 1080 by 720 pixels. The screen measures 10.2 centimeters diagonally. What is the approximate length, in centimeters, of the shortest side of the display?
A. 5.66 cm
B. 6.8 cm
C. 8.49 cm
D. 15.3 cm
Correct Answer: A
Difficulty Level: 4
41. Dennis Oppenheim designed an 18 foot ( ft ) high fiberglass safety cone statue for Seattle's Olympic Sculpture park. If the sculpture is similar to a typical safety cone with the dimensions shown above, what is the slant height of the safety cone statue to the nearest tenth of a foot?


Correct Answer: $\frac{183}{10}$
Difficulty Level: 4
42. A hanging planter has the dimensions shown to the left in inches (in). Each support cable is of equal length. The pot for the planter is a right rectangular prism. About what is the total height (from where the cables meet to the base of the

planter) of the hanging planter?
A. 21.28 in
B. 22.25 in
C. 29.28 in
D. 30.25 in

Correct Answer: C
Difficulty
Level: 4
43. Suppose that the interior of a hinged car door forms a $38^{\circ}$ angle with the body of the car when it is open. Given the measurements in the figure above, what is the width $w$, in inches, of the opening of the door? Round to the nearest inch.

Note: $\sin (19) \approx 0.326$ and $\tan (19) \approx 0.344$

$\square$

Correct Answer: 31
Difficulty Level: 4

## Congruence and similarity

1. 



In the figure above, $B C$ and $A D$ are parallel. What is the length, in centimeters (cm), of $B F$ ?


$$
\text { Correct answer: } 10
$$

Level: 3
2.


## Note: figure not drawn to scale

Triangles JKL and RST are shown above. Angles are given in radians, to the nearest hundredth. What is the value of $\theta$ in radians, to the nearest tenth?


Correct answer: 1.3
Level: 3
3.


In the diagram above, triangle $A F G$ is similar to triangle $A B C$. What is the measure of $\angle A G F$, in degrees?
$\square$

Correct answer: 78 Level: 3
4.


In the diagram at left, suppose $\mathbf{a}=\frac{\mathbf{2}}{\mathbf{3}} \boldsymbol{x}$. What is the measure
$\square$ of $\boldsymbol{x} \boldsymbol{?}$

## Correct answer: $54^{\circ}$

Level: 3

A. $A E$ bisects $\angle C A B$
B. $\angle A C B$ is congruent to $\angle A B C$
C. triangle $A B C$ is isosceles
D. $A E$ is a median of $\triangle A B C$

Level:

5. In the diagram at left,
$A D$ is congruent to $B D$.
Which of the following statements is true?

Correct
answer:
C 3

The diagram at left shows four lines: $A B, C D, A D$, and $B C$. Which of the following statements is true?
A. $\angle A B C$ measures $88^{\circ}$
B. $\angle B C D$ measures $80^{\circ}$
C. $A D$ intersects $B C$
D. $A D$ is parallel to $B C$

Level: 4

7. In the diagram at left, $A B$ is congruent to $B C$. Which of the following statements is true?
A. $\angle \mathrm{DAC}$ is congruent to $\angle$ DCA
B. $\angle \mathrm{BAC}$ is congruent to $\angle$ BCA
C. $\angle \mathrm{ABC}$ is congruent to $\angle \mathrm{ADC}$
D. $\angle \mathrm{BAD}$ is congruent to $\angle \mathrm{BCD}$

Correct
Level: 4

Isosceles triangles $A B C$ and $D E F$ shown above are similar triangles. The length $A B$ equals the length $B C$, and the length $D E$ equals the length $E F$. What is the value of $v$ in radians, to the nearest hundredth?


Correct answer: 2.09
Level: 4
9.


Given the lengths of the segments in the figure above, what is the length, to the nearest tenth, of $n$ ?

$$
\text { Correct answer: } \frac{\mathbf{4 2}}{\mathbf{5}}
$$

10. 



In the figure at left, lines $c$ and $d$ are parallel. What is the value of $x$ ?
$\square$

Correct answer: 8
Level: 4


Note: figure not drawn to scale

- Parallelogram $A B C D$ shown above is congruent to parallelogram $P Q R S$. What is the value of $a$ in radians, to the nearest hundredth?
$\square$

12. 



The diagram at left shows a rectangular billiard table with a width of 39 inches (in) and a length of 78 in . A player is trying to shoot the red ball located at point $H$, into the corner pocket $D$ by bouncing the ball off of a point $R$ that is $x$ inches from point $B$. The player knows that when the ball bounces off point $R, \angle H R B$ will be congruent to $\angle D R C$. If the point $\mathrm{B} B$ is the midpoint of $A C$ and the red ball is 15 in above $B$, approximately what is the value of $x$ ?
A. 7 in
B. 9 in
C. 11 in
D. 13 in

## Correct answer: C

Level: 4
13. Given the figure at left, which of the following statements must be true?

A. $A B$ is parallel to $D E$.
B. $C$ is the midpoint of $B D$.
C. Triangle $C B A$ is congruent to triangle $C D E$.
D. $\angle A B C$ and $\angle D C E$ are vertical angles.

Correct answer: A
Level: 4
14.


In triangle $A B C$ shown at left, tick marks of equal number represent sides of equal
length. Therefore, the point along line segment $A B$ is the midpoint of $A B$. What is the value of $\beta$ in terms of $\alpha$ and $t ?$
A. $\alpha$
B. $t$
C. $\frac{\pi}{2}-\alpha$
D. $\frac{\pi}{2}-\alpha$

Correct answer: B
Level: 4

15. In the diagram at left, line $v$ transverses lines $w, x, y, \quad$ and $z$. Given the angle measurements shown, which pair of lines is parallel?
A. Lines $w$ and $x$
B. Lines $y$ and $z$
C. Lines $w$ and $y$
D. Lines $x$ and $z$
16.


Both square $A B C D$ and square $E F G H$ shown at left have center $Q$. However, they do not have the same area. Which of the following must be true?
A. $\alpha=w \circ$
B. $\alpha 0=-w^{\circ}$
C. $\alpha \circ=90 \circ-w \circ$
D. $\alpha \circ=180 \circ-w^{\circ}$

## Right triangle trigonometry



1. The length of $A E$ is $2 \sqrt{ } 2$ in the figure shown at left. What is the length of $B E$ ?
A. 1
B. $\sqrt{2}$
C. $\frac{\sqrt{2}}{2}$
D. $\frac{1}{2}$

Correct answer: B
Level: 3


Note: figure not drawn to scale

Triangle $L U R$ has a uniform thickness of 2.5 , as shown at left. The length of $U D$, which is the height of the triangle, is $25 \sqrt{ } 3$. It is given that $\sqrt{ } 3 \approx 1.73$. The triangle has a right angle at vertex $U$ and an angle of $\frac{\pi}{6}$ vertex $R$. Given that the width, $w$, of the shaded triangle is 86.34 , what is the height, $h$, of the shaded triangle to the nearest tenth?
$\square$
3.


## Note: figure not arawh to scile

Side length $t$ is 6.43 and $s$ is 5.39. Given that $\frac{s}{t} \approx \tan (0.697) \approx \sin (0.994) \approx \cos (0.576)$, approximately what is angle $\beta$ in radians, to the nearest tenth?


Correct answer: 0.7
Level: 3

4. What is the length of $X Y$ in the figure shown at left?
A. 6
B. $4 \sqrt{3}$
C. $6 \sqrt{2}$
D. 12
5.


In the figure above, $F H$ has length $12, J K$ has length 7 , and the measure of angle $\angle$ $F G H$ is $\theta$ radians. It is given that $\frac{5}{7} \approx \tan (0.62) \approx \cot (0.95) \approx \sin (0.80) \approx \cos (0.78)$. Approximately what is the value of $\theta$ in radians to the nearest hundredth?
$\square$
Correct answer: 0.62
Level: 3
6.


In the figure at left, line segment $A B$ is vertical and $B C$ is horizontal. Line segment $B T$ has length 9 and is perpendicular to $A C$. The length of $B C$ is 15 . Approximately what is the value of $h$, to the nearest integer?



Quadrilateral CMLI above is a rectangle. Line segment $I M$ has length 3535 , and line segment $C M$ has length 30 . It is given that $\cos \left(\frac{30}{35}\right) \approx 0.655, \backslash \sin$ $\left(\frac{30}{35}\right) \approx 0.756, \cos (0.541) \approx \frac{30}{35}$, and $\sin (1.030) \approx \frac{30}{35}$. Approximately what is the measure of $\angle$ MIL in radians, to the nearest hundredth?
$\square$

Correct answer: 0.54
Level: 3
8.


What is the value of $\mathrm{x} x$ in the figure shown at left?


Correct answer: 60
Level: 3

9. What is the value of $\mathrm{X} x$ in the figure shown to the left?
A. $3 \sqrt{3}$
B. 12
C. 18
D. $12 \sqrt{3}$

Correct answer: 60
10. There is a vertical line of symmetry through the middle of the figure shown at left. Given that $\sin (22 \circ) \approx 0.37, \cos (22 \circ) \approx 0.93$, and $\tan (22 \circ) \approx 0.40$, approximately what is length $x$, to the nearest integer?


Correct answer: 13
Level: 3

11.


A large square has side length 320 . The square is at an angle of $\theta$ from vertical, as shown at left, where $\sin (\theta) \approx 0.54, \quad \cos (\theta) \approx 0.84, \quad$ and $\tan (\theta) \approx 0.64$. There are 22 dotted vertical line segments and 2 dotted horizontal line segments. Each dotted line segment coincides with a corner of the square. What is the side length, $l$, of the small square formed by the dotted line segments?
$\square$
12.


The 4 rectangles shown at left have the same width, $w$, and height, $h$. The horizontal distance between the rectangles must be $\frac{2}{3}$ the width of the rectangles, and the vertical distance must be $\frac{2}{3}$ the height of the rectangles. Angles $\alpha$ and $\beta$, in radians, are shown above. What is $\frac{\beta}{\alpha}$ expressed as a decimal, to the nearest hundredth?

13. The figure at left has a vertical line of symmetry down the middle. Length $x$ is 8 and length $y$ is 10 . Given that $\tan (0.4) \approx 0.423, \quad \tan (0.381) \approx 0.4$, $\tan (0.8) \approx 1.030$, and $\tan (0.675) \approx 0.8$, approximately what is the measure of angle $\theta$ in radians, to the nearest hundredth?


Correct answer: 0.76

14.


Triangles $\mathrm{ACD} A C D$ and ABCABC , shown at left, are both right triangles. The
measures of $\angle A D C$ and $\angle A C B$ are both $\gamma$. It is given that $\sin (\gamma) \approx 0.50, \cos (\gamma) \approx 0.87$, and $\tan (\gamma) \approx 0.58$. The bottom triangle has a fixed width of 10 feet ( ft ). Approximately what is the length of $D A$ in feet, to the nearest tenth of a foot?


Correct answer: 40
Level: 3
15.


The figure at left has a vertical line of symmetry in the middle. Half the length of the base is 4 feet $(\mathrm{ft})$. Angle $B O A$ is 30 and line segment $B A$ is 6 inches in length. Given that $\sqrt{3}$ $\approx 1.73$, approximately how tall is the figure in inches, to the nearest inch?


Correct answer: 28
Level: 3
16.


Given that $\frac{12}{13} \approx \tan (42.7 \circ) \approx \sin (67.4 \circ) \approx \cos (22.6 \circ)$, approximately what is the value of $\alpha$, to the nearest integer?
$\square$
17.


In the figure at left, $L=21$ and $y=11$. The rightmost angle has a measure of $20 \circ$. Line segments $A B$ and $C D$ are each perpendicular to the hypotenuse of the large triangle. Line segment $A B$ has length 5.5 . Given that $(20 \circ) \approx 0.342, \cos (20 \circ) \approx 0.940$, and $\tan (20 \circ) \approx 0.363$, approximately what is the value of $x$, to the nearest integer?


## Correct answer: 6

Level: 3
18. The length of $A E$ is $3 \sqrt{ } 3$ in the figure shown at left. What is the length of $A B$ ?


Correct answer: 2 Level: 3

shown at left. What is the length of $A E$ ?
$\square$

## Correct answer: 10

Level: 4
20.


It is given that $\sin (80 \circ) \approx 0.985, \cos \left(80^{\circ}\right) \approx 0.174$, and $\tan \left(80^{\circ}\right) \approx 5.671$. In the figure at left, $\angle J L K$ and $\angle M K L$ are right angles. What is the measurement of $\angle L J K$ to the nearest degree?


Correct answer: 30
Level: 4
21.


What is the value of $x$ in the figure shown at left?
$\square$

Correct answer: 4
Level: 4
22.


What is the value of $x$ in the figure shown at left?
$\square$

Correct answer: 6
Level: 4
23.


Side length $t$ is 6.43 and $s$ is 5.39. Given that $\frac{s}{t} \approx \tan (0.697) \approx \sin (0.994) \approx \cos (0.576)$, approximately what is angle $\beta$ in radians, to the nearest tenth?


## Correct answer: 0.7

Level: 4
24.


It is given that $\sin (58 \circ) \approx 0.85, \cos (58 \circ) \approx 0.53$, and $\tan (58 \circ) \approx 1.60$. In the figure at left, $\angle J M L$ and $\angle K M L$ are right angles. To the nearest tenth, what is $\tan \left(x_{\circ}\right)$ ?
$\square$

In the figure at left, $T R$ has length 1212. Given that $\sin (r \circ) \approx 0.927, \cos (r \circ) \approx 0.375$, and $\tan (r \circ) \approx 2.472$, which of the following is closest to the length of $R S$ ?
A. 4.9
B. 12.9
C. 29.7
D. 32.0

## Correct answer: D

$$
\text { Level: } 4
$$

26. 



What is the value of $x$ in the figure shown above?


Which expression is equivalent to $\sin 49 \circ$ in the right triangle shown above?
A. $\cos \angle C$
B. $\sin \angle C$
C. $\cos \angle A$
D. $\sin \angle B$

Correct answer: A
Level: 4
28.


What is the measure in degrees of $\angle M L N$ in the figure shown at left?
29.


A wall is made from rectangular bricks so that the right edge of each brick is vertically aligned with the right edge of the brick two rows above it, as shown at left. Every brick is 6 centimeters tall and 20 centimeters wide. The wall is 8.5 rows tall. The right triangle is drawn so that the hypotenuse intersects the top right corner of 9 bricks. What is the width $w$ of the right triangle in centimeters?


Correct answer: 85
Level: 4
30.

31.
the

$\begin{array}{llll}\text { Correct } & \text { answer: } & 16 & \sqrt{2}\end{array}$
Level: 4

In the figure to the left, $\sin (x \circ)=0.9$. Which of following is nearest to $\cos (90 \circ-x \circ)$ ?
A. 0.45
B. 0.90
C. 1.12
D. 1.96
32.


The figure at left is a stairway such that the bottom railing touches each step edge. The railing beam and the walls of the stairs are vertical. The angle of inclination $\theta$ is $\frac{\pi}{6}$. The floor of each step is horizontal. It is given that $\sqrt{ } 3 \approx 1.732$. What is $h$, the distance from the bottom of the support beam to the bottom railing in centimeters, to the nearest tenth of a centimeter?
$\square$
Correct answer: 3.5
Level: 4
33.


A series of identical rectangles are positioned so that the top-right corner of each rectangle is coincident with the bottom-left corner of the next rectangle. There are a total of 1010 rectangles, but only 44 are shown at left. The width of a rectangle is 11 . The angle of inclination of one rectangle to the next is $t$. It is given that $\sin (t) \approx 0.25, \cos (t) \approx 0.97$, and $\tan (t) \approx 0.26$. Which of the following is closest to the height, $h$, of the series of rectangles?
A. 2.5
B. 2.6
C. 38.5
D. 40

Level: 4

Correct answer: B
34.
at

W



It is given that $\sqrt{ } 3 \approx 1.732$. It is given that $\sin (65 \circ) \approx 0.91, \cos \left(65^{\circ}\right) \approx 0.42$, and $\tan \left(65^{\circ}\right) \approx 2.14$. In the diagram at left, $\angle A D B$ and $\angle C D B$ are right angles. What is the length of $A C$ to the nearest integer?


## Angles, arc lengths, and trig functions

1. 



Which of the following is the measure of the above angle in degrees?
A. $180^{\circ}$
B. $195^{\circ}$
C. $210^{\circ}$
D. $225^{\circ}$

Correct answer: B Difficulty level: 2
2.


Which of the following is the measure of the above angle in degrees?
A. $120^{\circ}$
B. $135^{\circ}$
C. $150^{\circ}$
D. $210^{\circ}$

Correct answer: C Difficulty level: 2
3. If $\theta=\frac{4 \pi}{9}$ radians, what is the value of $\theta$ in degrees?
A. $20^{\circ}$
B. $36^{\circ}$
C. $80^{\circ}$
D. $720^{\circ}$

Correct answer: C Difficulty level: 2
4. If $\theta=240^{\circ}$, what is the value of $\theta$ in radians?
A. $\frac{2 \pi}{3}$
B. $\frac{7 \pi}{6}$
C. $\frac{4 \pi}{3}$
D. $\frac{3 \pi}{2}$

Correct answer: C Difficulty level: 2
5. If $\theta=315^{\circ}$, what is the value of $\theta$ in radians?
A. $\frac{5 \pi}{4}$
B. $\frac{3 \pi}{2}$
C. $\frac{5 \pi}{3}$
D. $\frac{7 \pi}{4}$

Correct answer: D Difficulty level: 2
6. Which of the following is the value of $\tan \left(225^{\circ}\right)$ ?
A. -1
B. $-\frac{\sqrt{2}}{2}$
C. $\frac{\sqrt{2}}{2}$
D. 1

Correct answer: D Difficulty level: 2
7.


In the circle C shown at left, a central angle of $150^{\circ}$ intercepts an arc $15 \pi$ centimeters ( cm ) in
length. Which of the following best approximates the length of the radius of the circle?
A. 0.3 cm
B. 2.6 cm
C. 5 cm
D. 18 cm

Correct answer: D Difficulty level: 3
8.


Which of the following is the measure of the above angle in radians?
A. $\frac{5 \pi}{3}$
B. $\frac{7 \pi}{4}$
C. $\frac{11 \pi}{6}$
D. $\frac{23 \pi}{12}$

Correct answer: A Difficulty level: 3
9. A circle has a circumference of $12 \pi$ feet ( ft ). An arc, x , in this circle has a central angle of $45^{\circ}$. What is the length of $x$ ?
A. $\frac{3 \pi}{2} f t$
B. $3 \pi f t$
C. 270 ft
D. 540 ft

Correct answer: A Difficulty level: 3
10. Which of the following is the value of $\sin \left(\frac{\pi}{2}\right)$ ?
A. -1
B. 0
C. $\frac{\sqrt{2}}{2}$
D. 1

Correct answer: D Difficulty level: 3
11. If $\theta=\frac{\pi}{2}$ radians, which of the following shows the measure of $\theta$ in degrees?
A. $45^{\circ}$
B. $90^{\circ}$
C. $135^{\circ}$
D. $180^{\circ}$

Correct answer: B Difficulty level: 3
12.


In the diagram at left, circle C has a radius of 6 feet (ft). Which of the following best approximates the measure of the arc length $s$ ?
A. 23 ft
B. 46 ft
C. 220 ft
D. 1320 ft

Correct answer: A Difficulty level: 4
13.


In a circle with center $C$ and radius 4 meters ( $m$ ), a central angle of $x^{\circ}$ intercepts an arc of 20 m as shown in the diagram at left. Rounded to the nearest degree, which of the following best approximates the value of $x$ ?
A. 5
B. 80
C. 286
D. 304

Correct answer: C Difficulty level: 4
14. Which of the following is the value of $\sin \left(\frac{5 \pi}{6}\right)$ ?
A. $-\frac{\sqrt{3}}{2}$
B. $-\frac{\sqrt{2}}{2}$
C. $\frac{1}{2}$
D. 150

Correct answer: C Difficulty level: 4
15. Which of the following is the value of $\sin \left(\frac{\pi}{3}\right)$ ?
A. $\frac{1}{2}$
B. $\frac{\sqrt{3}}{3}$
C. $\frac{\sqrt{3}}{2}$
D. $\sqrt{3}$

Correct answer: D Difficulty level: 4
16.


Which of the following is the value of the sine of the angle shown above?
A. $-\frac{\sqrt{2}}{2}$
B. $\frac{\sqrt{2}}{2}$
C. 45
D. 315

Correct answer: A Difficulty level: 4
17.


Which of the following is the value of the cosine of the angle shown above?
A. $\frac{1}{2}$
B. $\frac{\sqrt{3}}{3}$
C. $\frac{\sqrt{3}}{2}$
D. $\sqrt{3}$

Correct answer: C Difficulty level: 4

## Circle theorems

1. 



The semicircle shown at left has center at point $O$. The shaded sector of the circle formed by angle NOM has area 6.25 . The radius of the semicircle is 2.5 . What is the radian measure of angle LON, shown by a in the figure?
A. 2
B. 2.5
C. $\pi-2$
D. $\pi-2.5$

Correct answer: C Difficulty level: 2
2.


The circle shown at left has its center at point O . Line segment $\overline{\mathrm{MN}}$ is a diameter. The measure of acute angle LOM is 0.6 radians. The shaded sector of the circle formed by the obtuse angle LON has area 6 . What is the radius, r , of the circle?
A. $\frac{3}{\pi-0.6}$
B. $\frac{12}{\pi-0.6}$
C. $\sqrt{\frac{3}{\pi-0.6}}$
D. $\sqrt{\frac{12}{\pi-0.6}}$

Correct answer: D Difficulty level: 2
3.


The sector of a circle shown at left has center $Z$. The length of the chord $\overline{X Y}$ is 24 . The distance from $Z$ to the chord $\overline{X Y}$ is 5 , shown by $\overline{W Z}$. Finally, $\overline{W Z}$ is perpendicular to $\overline{X Y}$ and bisects $\overline{\mathrm{XY}}$ at W . What is the radius, r , of the circle?
A. $\sqrt{120}$
B. 13
C. 17
D. $\sqrt{601}$

Correct answer: B Difficulty level: 2
4.


The sector of a circle shown at left has center at point $O$. The radius of the circle has length 1.4 and arc ADC has length 2.1. Line segment $\overline{\mathrm{OB}}$ is perpendicular to chord $\overline{\mathrm{AC}}$ and bisects angle AOC. What is the length, $l$, of chord $\overline{\mathrm{AC}}$ ?
A. $2.8 \sin (0.75)$
B. $2.8 \cos (0.75)$
C. $1.4 \sin (1.5)$
D. $1.4 \cos (1.5)$

Correct answer: A Difficulty level: 2


A metal wedge to be used as a corner brace has the shape of the quarter circle shown at left. Angle ACB is a right angle, and the length of the chord $\overline{\mathrm{AB}}$ is 2 centimeters (cm). What is the length of the arc ADB?
A. $\frac{\pi}{2} \mathrm{~cm}$
B. $\frac{\sqrt{2} \pi}{2} \mathrm{~cm}$
C. $\pi \mathrm{cm}$
D. $\sqrt{2} \pi \mathrm{~cm}$

Correct answer: B Difficulty level: 2
6. If $\theta=315^{\circ}$, what is the value of $\theta$ in radians?
A. $\frac{5 \pi}{4}$
B. $\frac{3 \pi}{2}$
C. $\frac{5 \pi}{3}$
D. $\frac{7 \pi}{4}$

Correct answer: D Difficulty level: 1
7.


In a circle with center C and radius 28 meters ( m ), a central angle of $x^{\circ}$ intercepts an arc of $4 \pi$ m as shown in the figure at left. Rounded to the nearest degree, which of the following best approximates the value of $x$ ?
A. 7
B. 13
C. 26
D. 45

Correct answer: C Difficulty level: 1
8. If $\theta=\frac{4 \pi}{9}$ radians, what is the value of $\theta$ in degrees?
A. $20^{\circ}$
B. $36^{\circ}$
C. $80^{\circ}$
D. $720^{\circ}$

Correct answer: C Difficulty level: 1
9. Which of the following is the value of $\cos \left(210^{\circ}\right)$ ?
A. $-\frac{\sqrt{3}}{2}$
B. $-\frac{1}{2}$
C. $\frac{1}{2}$
D. $\frac{\sqrt{3}}{2}$

Correct answer: A Difficulty level: 1
10. Which of the following is the value of $\sin \left(\frac{5 \pi}{6}\right)$ ?
A. $-\frac{\sqrt{3}}{2}$
B. $-\frac{\sqrt{2}}{2}$
C. $\frac{1}{2}$
D. 150

Correct answer: C Difficulty level: 1
11. What is the length of arc S shown below?

## $\square$ units



The angle in the figure is a central angle in radians.

## Correct answer: 24 Difficulty level: 1

12. What is the measure of $\theta$ in radians?
$\square$ radians


In the diagram, $\theta$ is a central angle.

Correct answer: 1.5 Difficulty level: 1
13. An arc is subtended by a central angle measuring $\frac{7 \pi}{4}$ radians. What fraction of the circumference is this arc?
$\square$ of the circumference


Correct answer: 0.875 Difficulty level: 1
14. An arc is subtended by a central angle measuring $\frac{5 \pi}{6}$ radians. What fraction of the circumference is this arc?
$\qquad$ of the circumference


Correct answer: 0.4166666666666667 Difficulty level: 1
15. What is the measure of $\theta$ in radians?
$\square$ radians


In the diagram, $\theta$ is a central angle.

Correct answer: 5 Difficulty level: 1
16. What is the length of arc S shown below?
$\square$ units


The angle in the figure is a central angle in radians.

Correct answer: 2 Difficulty level: 1
17. An arc is subtended by a central angle measuring $\frac{5 \pi}{11}$ radians. What fraction of the circumference is this arc?
$\qquad$


Correct answer: 0.22727272727272727 Difficulty level: 1
18.


The circle shown to the left with area $9 \pi$ has a sector with a central angle of $\frac{1}{9 \pi}$ radians.
What is the area of the sector?
A. $\frac{1}{2} \pi$
B. $\frac{1}{162} \pi$
C. $2 \pi$
D. $162 \pi$

Correct answer: A Difficulty level: 1
19.


The circle shown to the left with area $36 \pi$ has a sector with a central angle of $48^{\circ}$.
What is the area of the sector?
A. $\frac{5}{24} \pi$
B. $\frac{1}{270} \pi$
C. $270 \pi$
D. $\frac{24}{5} \pi$

Correct answer: D Difficulty level: 1
20.


The circle shown to the left has a sector with area $\frac{24}{5} \pi$ and central angle of $192^{\circ}$.
What is the area of the circle?
A. $\frac{1}{9} \pi$
B. $9 \pi$
C. $\frac{75}{192} \pi$
D. $\frac{192}{75} \pi$

Correct answer: B Difficulty level: 1
21.


The circle shown to the left has a sector with area $15 \pi$ and central angle of $216^{\circ}$. What is the area of the circle?
A. $\frac{1}{9} \pi$
B. $9 \pi$
C. $\frac{1}{25} \pi$
D. $25 \pi$

Correct answer: D Difficulty level: 1
22.


The circle shown to the left with area $100 \pi$ has a sector with a central angle of $\frac{2}{5} \pi$ radians.
What is the area of the sector?
A. $\frac{1}{500} \pi$
B. $20 \pi$
C. $\frac{1}{80} \pi$
D. $80 \pi$

Correct answer: B Difficulty level: 1
23.


The circle shown to the left with radius 3 has a sector with a central angle of $160^{\circ}$. What is the area of the sector?
A. $\frac{1}{4} \pi$
B. $\frac{4}{81} \pi$
C. $4 \pi$
D. $\frac{81}{4} \pi$

Correct answer: C Difficulty level: 1
24.


The circle shown to the left with area $25 \pi$ has a sector with a central angle of $\frac{9}{10} \pi$ radians.
What is the area of the sector?
A. $\frac{4}{45} \pi$
B. $\frac{45}{4} \pi$
C. $\frac{9}{500} \pi$
D. $\frac{500}{9} \pi$

Correct answer: B Difficulty level: 1
25.


The circle shown to the left has a sector with area $2 \pi$ and central angle of $\frac{1}{4} \pi$ radians.
What is the area of the circle?
A. $\frac{1}{4} \pi$
B. $4 \pi$
C. $\frac{1}{16} \pi$
D. $16 \pi$

Correct answer: D Difficulty level: 1
26.


The circle shown to the left with area $9 \pi$ has a sector with a central angle of $\frac{17}{9} \pi$ radians.
What is the area of the sector?
A. $\frac{17}{2} \pi$
B. $\frac{2}{17} \pi$
C. $\frac{17}{162} \pi$
D. $\frac{162}{17} \pi$

Correct answer: A Difficulty level: 1
27.


The circle shown to the left with radius 2 has a sector with a central angle of $\frac{3}{2} \pi$ radians.
What is the area of the sector?
A. $\frac{1}{3} \pi$
B. $\frac{3}{16} \pi$
C. $3 \pi$
D. $\frac{16}{3} \pi$

Correct answer: C Difficulty level: 1
28.


The circle shown to the left with area $81 \pi$ has a sector with a central angle of 120 . What is the area of the sector?
A. $\frac{1}{243} \pi$
B. $\frac{1}{27} \pi$
C. $27 \pi$
D. $243 \pi$

Correct answer: C Difficulty level: 1
29.


The circle shown to the left has a sector with area $\frac{10}{3} \pi$ and central angle of $12^{\circ}$.
What is the area of the circle?
A. $9 \pi$
B. $100 \pi$
C. $\frac{1}{9} \pi$
D. $\frac{1}{100} \pi$

Correct answer: B Difficulty level: 1
30.


The circle shown to the left has a sector with area $\frac{81}{2} \pi$ and central angle of $180^{\circ}$.
What is the area of the circle?
A. $162 \pi$
B. $\frac{1}{162} \pi$
C. $\frac{1}{81} \pi$
D. $81 \pi$

Correct answer: D Difficulty level: 1
31.


The circle shown to the left has a sector with area $\frac{125}{6} \pi$ and central angle of $300^{\circ}$.
What is the area of the circle?
A. $\frac{36}{625} \pi$
B. $\frac{1}{25} \pi$
C. $\frac{625}{36} \pi$
D. $25 \pi$

Correct answer: D Difficulty level: 1
32.


The circle shown to the left with radius 7 has a sector with a central angle of 280 . What is the area of the sector?
A. $\frac{343}{9} \pi$
B. $\frac{1}{63} \pi$
C. $63 \pi$
D. $\frac{9}{343} \pi$

Correct answer: A Difficulty level: 1
33. The circle shown to the left with radius 3 has a sector with a central angle of $\pi$ radians. What is the area of the sector?
A. $\frac{2}{9} \pi$
B. $\frac{1}{18} \pi$
C. $18 \pi$
D. $\frac{9}{2} \pi$

Correct answer: D Difficulty level: 1
34. The circle shown to the left has a sector with area $\frac{36}{5} \pi$ and central angle of $288^{\circ}$.

What is the area of the circle?
A. $9 \pi$
B. $\frac{25}{144} \pi$
C. $\frac{144}{25} \pi$
D. $\frac{1}{9} \pi$

Correct answer: A Difficulty level: 1
35.


The circle shown to the left with radius 4 has a sector with a central angle of $\pi$ radians. What is the area of the sector?
A. $\frac{1}{8} \pi$
B. $\frac{1}{32} \pi$
C. $8 \pi$
D. $32 \pi$

Correct answer: C Difficulty level: 1
36.


The circle shown to the left with radius 8 has a sector with a central angle of $\pi$ radians. What is the area of the sector?
A. $\frac{1}{32} \pi$
B. $\frac{1}{128} \pi$
C. $128 \pi$
D. $32 \pi$

Correct answer: D Difficulty level: 1
37.


The circle shown to the left has a sector with area $\frac{70}{3} \pi$ and central angle of $84^{\circ}$.
What is the area of the circle?
A. $10 \pi$
B. $\frac{49}{9} \pi$
C. $\frac{490}{9} \pi$
D. $100 \pi$

Correct answer: D Difficulty level: 1
38.


The circle shown to the left with area $36 \pi$ has a sector with a central angle of $\frac{11}{6} \pi$ radians.
What is the area of the sector?
A. $\frac{432}{11} \pi$
B. $\frac{11}{432} \pi$
C. $33 \pi$
D. $132 \pi$

Correct answer: C Difficulty level: 1
39.


The circle shown to the left with radius 10 has a sector with a central angle of $\frac{8}{15} \pi$ radians.
What is the area of the sector?
A. $\frac{80}{3} \pi$
B. $\frac{3}{80} \pi$
C. $\frac{1}{300} \pi$
D. $300 \pi$

Correct answer: A Difficulty level: 1
40.


A circle with radius 3 has a sector with a central angle of $\frac{11}{15} \pi$ radians.
What is the area of the sector?
A. $\frac{10}{33} \pi$
B. $\frac{11}{270} \pi$
C. $\frac{33}{10} \pi$
D. $\frac{270}{11} \pi$

Correct answer: C Difficulty level: 1
41.


The circle shown to the left with area $9 \pi$ has a sector with a central angle of $45^{\circ}$.
What is the area of the sector?
A. $\frac{1}{72} \pi$
B. $72 \pi$
C. $\frac{8}{9} \pi$
D. $\frac{9}{8} \pi$

Correct answer: D Difficulty level: 1
42.


The circle shown to the left with area $16 \pi$ has a sector with a central angle of $\frac{8}{5} \pi$ radians.
What is the area of the sector?
A. $\frac{64}{5} \pi$
B. $\frac{5}{64} \pi$
C. $\frac{1}{20} \pi$
D. $20 \pi$

Correct answer: A Difficulty level: 1
43.


The circle shown to the left with radius 7 has a sector with a central angle of $72^{\circ}$.
What is the area of the sector?
A. $\frac{49}{5} \pi$
B. $\frac{5}{49} \pi$
C. $\frac{1}{245} \pi$
D. $245 \pi$

Correct answer: A Difficulty level: 1
44.


The circle shown to the left has a sector with area $\frac{147}{5} \pi$ and central angle of $\frac{6}{5} \pi$ radians.
What is the area of the circle?
A. $\frac{1}{49} \pi$
B. $49 \pi$
C. $\frac{25}{441} \pi$
D. $\frac{441}{25} \pi$

Correct answer: B Difficulty level: 1
45.


The circle shown to the left with area $9 \pi$ has a sector with a central angle of $60^{\circ}$.
What is the area of the sector?
A. $\frac{2}{3} \pi$
B. $\frac{3}{2} \pi$
C. $\frac{1}{54} \pi$
D. $54 \pi$

Correct answer: B Difficulty level: 1
46.


The circle shown to the left with radius 6 has a sector with a central angle of $48^{\circ}$. What is the area of the sector?
A. $\frac{5}{24} \pi$
B. $\frac{24}{5} \pi$
C. $\frac{1}{270} \pi$
D. $270 \pi$

Correct answer: B Difficulty level: 1
47.


The circle shown to the left has a sector with area $\frac{279}{4} \pi$ and central angle of $310^{\circ}$.
What is the area of the circle?
A. $81 \pi$
B. $\frac{1}{81} \pi$
C. $\frac{9}{144} \pi$
D. $\frac{144}{9} \pi$

Correct answer: A Difficulty level: 1
48.


The circle shown at left has center at point O . Chord $\overline{\mathrm{AC}}$ is perpendicular to radius $\overline{\mathrm{OD}}$ and intersects $\overline{\mathrm{OD}}$ at point B . Line segment $\overline{\mathrm{OB}}$ has length 8 and line segment $\overline{\mathrm{BD}}$ has length 9 . What is the length of chord $\overline{\mathrm{AC}}$ ?
A. $2 \sqrt{145}$
B. 30
C. $24 \sqrt{2}$
D. 34

Correct answer: B Difficulty level: 2
49.


Anatoli is making a cement step for his patio in the shape of a sector of a circle as shown above. He has enough cement to fill an area of 3.6 square meters $\left(\mathrm{m}^{2}\right)$ such that the central angle is 1.2 radians. What must be the radius of the circular sector, r , according to this design?
A. $\sqrt{3}$ meters
B. $\sqrt{6}$ meters
C. 3 meters
D. 6 meters

Correct answer: B Difficulty level: 3
50.


In the figure at left, point C is the center of the circle. Line segment $\overline{\mathrm{CD}}$ is perpendicular to line segment $\overline{\mathrm{AB}}$ and bisects $\overline{\mathrm{AB}}$ at the point E . It is known that $\overline{\mathrm{AB}}$ and $\overline{\mathrm{CD}}$ have length 10. What is the length of $\overline{\mathrm{CE}}$ ?
A. 5
B. $3 \sqrt{3}$
C. 7.5
D. $5 \sqrt{3}$

Correct answer: D Difficulty level: 3
51.


The figure at left shows a sector of a circle of radius 5 with a center at point O . The area of the shaded sector is $20 \pi$. The arc of the sector has endpoints M and N . What is the length, $l$, of line segment $\overline{\mathrm{MN}}$ ?
A. $5 \sin \left(\frac{\pi}{5}\right)$
B. $10 \sin \left(\frac{\pi}{5}\right)$
C. $5 \sin \left(\frac{2}{5} \pi\right)$
D. $10 \sin \left(\frac{2}{5} \pi\right)$

Correct answer: B Difficulty level: 3
52.


The sector of a circle shown at left has central angle NOP with a measure of 2.1 radians. The original circle has a diameter of 8 . What is the area of the sector?
A. 4.2
B. 8.4
C. 16.8
D. 33.6

Correct answer: C Difficulty level: 3
53.


In the figure at left, point $C$ is the center of the circle. Line segment $\overline{\mathrm{AC}}$ has length 6 , and angle BCE has measure $\frac{2 \pi}{3}$ radians. What is the length of arc BDE?
A. $\frac{9}{\pi}$
B. $4 \pi$
C. $8 \pi$
D. $12 \pi$

Correct answer: B Difficulty level: 3
54.


The sector of a circle shown at left has its center at point $A$. The length of $\overline{\mathrm{AC}}$ is 8 . Line segments $\overline{\mathrm{AD}}$ and $\overline{\mathrm{BC}}$ are perpendicular and intersect at point E such that $\overline{\mathrm{DE}}$ has length 1 . What is the length of chord $\overline{\mathrm{BC}}$ ?
A. $2 \sqrt{15}$
B. 8
C. $2 \sqrt{17}$
D. 9

Correct answer: A Difficulty level: 4
55.


The sector of a circle shown above has center at O . Radius $\overline{\mathrm{OW}}$ is perpendicular to chord $\overline{\mathrm{XY}}$ and intersects $\overline{X Y}$ at point $Z$. The length of $\overline{W Z}$ is 9 and the length of $\overline{\mathrm{XZ}}$ is 12 . To the nearest tenth, what is the radius, r , of the circle?

Correct answer: 12.5 Difficulty level: 4
56.


The semicircle shown above has its center at point O . The diameter of the circle is 30 , and the arc YXZ has length 18. To the nearest hundredth of a radian, what is the measure, a, of angle YOZ?

Correct answer: 1.2 Difficulty level: 4
57.


The sector of a circle shown above has center at O . The radius of the circle has length 5 . The arc XZY has length 7. To the nearest tenth, what is the shaded area of the sector?

Correct answer: 17.5 Difficulty level: 4
58.


The sector of a circle shown at left has center C . The total area of the sector is 500 . In addition, $\operatorname{arc} \mathrm{ABD}$ has length 40 . What is the length, $l$, of line segment $\overline{A C}$ ?
A. 12.5
B. 16
C. 20
D. 25

Correct answer: D Difficulty level: 4
59.


The sector of a circle shown above has its center at point O . The radius, OX, of the circular sector is 8 , and the area of the sector is 120 . To the nearest hundredth of a radian, what is the measure, a, of central angle XOY?

Correct answer: 3.75 Difficulty level: 4
60.


A sector of a circle is shown at left with center at point C and central angle x . The radius of the circular sector is 15 . The arc formed by central angle x from point A to point B has length 12. What is the measure of angle x in radians?
A. 0.8
B. 1.25
C. $0.8 \pi$
D. $1.25 \pi$

Correct answer: A Difficulty level: 4

## Circle equation

1. $(x-17)^{2}+(y-19)^{2}=49$

A circle in the $x y$-plane has the equation shown above. How long is the radius of the circle?
Correct answer: 7 Difficulty level: 2
2. A circle in the $x y$-plane has the equation $(x+17.5)^{2}+(y-15.3)^{2}=18.1$

Which of the following best describes the location of the center of the circle and the length of its radius?
A. Center:(-17.5,15.3)

Radius: $\sqrt{18.1}$
B. Center: $(-17.5,15.3)$ Radius:18.1
C. Center:(17.5,-15.3) Radius: $\sqrt{ } 18.1$
D. Center:(17.5,-15.3) Radius:18.1
Correct answer: A Difficulty level: 2
3. A circle in the $x y$-plane has the equation: $3.5(x+2.2)^{2}+3.5(y-11.1)^{2}-21=0$

What is the radius of the circle? Round the answer to the nearest tenth.
Correct answer:2.4 Difficulty level:2
4. $(x+16)^{2}+(y-25)^{2}=36$

A circle in the $x y$-plane has the equation shown above. Which of the following correctly describes the location of the center of the circle and the length of its radius?
A. Center: $(16,-25)$

Radius: 6
B. Center:(-16,25)

Radius:36
C. Center: $(-16,25)$ Radius:6
D. Center: $(16,-25)$

Radius:36
Correct answer:C Difficulty level:2
5. $(x+55)^{2}+(y-11.5)^{2}=121$

A circle in the $x y$-plane has the equation shown above. What is the length of the diameter of the circle?
Correct answer:22 Difficulty level:2
6.A circle in the $x y$-plane has its center at $(44,-34)$ and radius $\sqrt{3}$
. Which of the following is an equation of the circle?
A. $(x+34)^{2}+(y-44)^{2}=3$
B. $(x+34)^{2}+(y-44)^{2}=\sqrt{3}$
C. $(x-44)^{2}+(y+34)^{2}=3$
D. $(x-44)^{2}+(y+34)^{2}=\sqrt{3}$

Correct answer: C Difficulty level:2
7.A circle in the $x y$-plane has its center on the line $y=1$.If the point $(2,3)$ lies on the circle and the radius is 4 , which of the following could be the center of the circle?
A. $(2,1)$
B. $(2,-3)$
C. $(4,1)$
D. $(4,-1)$

Correct answer:A Difficulty level:2
8. A circle in the $x y$-plane has its center at $\left(-\frac{2}{3},-\frac{3}{4}\right)$ and radius 5 . Which of the following is an equation of the circle?
A. $\left(x+\frac{2}{3}\right)^{2}+\left(y+\frac{3}{4}\right)^{2}=5$
B. $\left(x-\frac{2}{3}\right)^{2}+\left(y+\frac{3}{4}\right)^{2}=25$
C. $\left(x+\frac{2}{3}\right)^{2}+\left(y-\frac{3}{4}\right)^{2}=25$
D. $\left(x+\frac{2}{3}\right)^{2}+(y+34)^{2}=25$

Correct answer:D Difficulty level:2
9.A circle with center $M$ is graphed in the $x y$-plane below.


Which of the following is an equation of the circle?
A. $(x+8)^{2}+y^{2}=100$
B. $(x+8)^{2}+(y+8)^{2}=100$
C. $(x+8)^{2}+(y-6)^{2}=100$
D. $(x+8)^{2}+(y+6)^{2}=100$

Correct answer:B Difficulty level:2
10.A circle in the $x y$-plane has the equation $x^{2}+y^{2}-14 y-51=0$

What is the center of the circle?
A. $(51,14)$
B. $(7,10)$
C. $(0,0)$
D. $(0,7)$

Correct answer:D Difficulty level:2
11.A circle in the $x y$-plane has its center at $(11,12)$. If the point $(13,14)$ lies on the circle, which of the following is an equation of the circle?
A. $x^{2}+y^{2}-22 x+24 y=-257$
B. $\mathrm{x}^{2}+y^{2}+22 x-24 y=-257$
C. $\mathrm{x}^{2}+y^{2}+22 x+24 y=-257$
D. $\mathrm{x}^{2}+y^{2}-22 x-24 y=-257$

Correct answer:D Difficulty level:2
12. A circle in the $x y$-plane has a center at $(-32.7,-9.08)$ and a radius of $\sqrt{10}$. Which of the following is an equation of the circle?
A. $(x+32.7)^{2}+(y+9.08)^{2}=\sqrt{ } 10$
B. $(x+32.7)^{2}+(y+9.08)^{2}=\sqrt{ } 20$
C. $(x+32.7)^{2}+(y+9.08)^{2}=10$
D. $(x+32.7)^{2}+(y+9.08)^{2}=100$

Correct answer:C Difficulty level:3
13. $(x+20)^{2}+(y-30)^{2}=225$

A circle in the $x y$-plane has the equation shown above. What is the $y$-coordinate of the center of the circle?
Correct answer:30 Difficulty level:3
14.A circle in the $x y$-plane has its center at the point $(-6,1)$. If the point $(7,12)$ lies on the circle, what is the radius of the circle? Round the answer to the nearest tenth.

Correct answer:17 Difficulty level:3
15. A circle in the $x y$-plane has the equation: $36 x^{2}+36 y^{2}-12 x-27 y-8=0$.

How long is the radius of the circle?
A. $\frac{5}{8}$
B. $\frac{25}{64}$
C. $\frac{2}{9}$
D. $\frac{\sqrt{ } 2}{3}$

Correct answer:A Difficulty level:3
16.A circle in the $x y$-plane has its center at $(-2.8,6.1)$ and radius 4.2. Which of the following is an equation of the circle?
A. $(x-2.8)^{2}+(y+6.1)^{2}=17.64$
B. $(x+2.8)^{2}+(y+6.1)^{2}=17.64$
C. $(x+2.8)^{2}+(y-6.1)^{2}=17.64$
D. $(x-2.8)^{2}+(y-6.1)^{2}=17.64$

Correct answer:C Difficulty level:3
17.A circle in the $x y$-plane has the equation $(x+18.5)^{2}+(y-3.1)^{2}=71$.What is the center of the circle?
A. $(-18.5,3.1)$
B. $(18.5,-3.1)$
C. $(-342.25,9.61)$
D. $(342.25,-9.61)$

Correct answer:A Difficulty level:3
18.A circle in the $x y$-plane has its center on the line $x=3$. If the point $(4,5)$ lies on the circle and the radius is $\sqrt{2}$, which of the following could be the center of the circle?
A. $(3,3)$
B. $(3,4)$
C. $(3,5)$
D. $(3,7)$

Correct answer:B Difficulty level:3
19. A circle in the $x y$-plane contains the points $(-1,1),(1,1)$, and $(-1,-1)$. Which of the following is an equation of the circle?
A. $x^{2}+$
B.
C.
D.

Correct answer:A Difficulty level:3
20.A circle in the $x y$-plane has its center at the point $(0.4,-0.3)$. If the point $(6,5)$ lies on the circle, what is the diameter of the circle? Round the answer to the nearest tenth.
A.7.7units
B.15.4units
C.59.5units
D.119units

Correct answer:B Difficulty level:3
21. A circle in the $x y$-plane has a center at $(-100,221)$ and a diameter of 17 . Which of the following is an equation of the circle?
A. $(x+100)^{2}+(y-221)^{2}=72.25$
B. $(x+100)^{2}+(y-221)^{2}=289$
C. $(x-100)^{2}+(y+221)^{2}=72.25$
D. $(x-100)^{2}+(y+221)^{2}=289$

Correct answer:A Difficulty level:3
22.A circle in the $x y$-plane has the equation: $\left(y-\frac{4}{5}\right)^{2}+\left(x+\frac{7}{10}\right)^{2}-30=0$

What is the radius of the circle? Round the answer to the nearest tenth.
Correct answer:5.5 Difficulty level:3
23.A circle in the $x y$-plane has the equation: $x^{2}+y^{2}-22 x+30 y+90=0$

How long is the diameter of the circle?
Correct answer:32 Difficulty level:4
24. A circle in the $x y$-plane has a diameter with endpoints at $(0,3)$ and $(-4,0)$. Which of the following is an equation of the circle?
A. $(x+4)^{2}+(y-3)^{2}=\frac{5}{4}$
B. $\left(x-\frac{3}{2}\right)^{2}+(y+2)^{2}=\frac{25}{2}$
C. $(x+2)^{2}+\left(y-\frac{3}{2}\right)^{2}=\frac{5}{2}$
D. $(x+2)^{2}+\left(y-\frac{3}{2}\right)^{2}=\frac{25}{4}$

Correct answer:D Difficulty level:4
25.A circle in the $x y$-plane has the equation: $x^{2}+y^{2}-10 x+32 y+272=0$

Which of the following best describes the location of the center of the circle and the length of its radius?
A. Center:(10,-32)

Radius: $4 \sqrt{7}$
B. Center:(-10,32)

Radius: $4 \sqrt{ } 17$
C. Center: $(-5,16)$

Radius:3
D. Center: $(5,-16)$

Radius:3
Correct answer:D Difficulty level:4
26.A circle in the $x y$-plane has the equation $4 x^{2}+4 y^{2}-24 x=28$. What is the diameter of the circle?
Correct answer:8 Difficulty level:4
27.A circle in the $x y$-plane has a diameter with endpoints at $(16,-25)$ and $(4,13)$. Which of the following is an equation of the circle?
A. $(x+6)^{2}+(y-10)^{2}=397$
B. $(x-10)^{2}+(y-6)^{2}=1588$
C. $(x-10)^{2}+(y+6)^{2}=1588$
D. $(x-10)^{2}+(y+6)^{2}=397$

Correct answer:D Difficulty level:4
28.A circle in the $x y$-plane has its center at. If the point $\left(0, \frac{5}{6}\right)$ lies on the circle, which of the following is an equation of the circle?
A. $\left(x-\frac{1}{2}\right)^{2}+\left(y+\frac{2}{3}\right)^{2}=\frac{5}{2}$
B. $\left(x-\frac{1}{2}\right)^{2}+\left(y-\frac{2}{3}\right)^{2}=\frac{5}{2}$
C. $\left(x-\frac{1}{2}\right)^{2}+\left(y+\frac{2}{3}\right)^{2}=5$
D. $\left(x+\frac{2}{3}\right)^{2}+\left(y-\frac{1}{2}\right)^{2}=\frac{5}{2}$

Correct answer:A Difficulty level:4
29.A circle in the $x y$-plane has a diameter with endpoints at $(-41,69)$ and $(31,-85)$. Which of the following is an equation of the circle?
A. $(x+41)^{2}+(y-69)^{2}=28900$
B. $(x+5)^{2}+(y+8)^{2}=7225$
C. $(x-31)^{2}+(y+85)^{2}=28900$
D. $(x+10)^{2}+(y+16)^{2}=7225$

Correct answer:B Difficulty level:4
30.A circle in the $x y$-plane has the equation: $2 \mathrm{x}^{2}+2 \mathrm{y}^{2}-8 x-5 y-\frac{55}{8}=0$

What is the diameter of the circle?
Correct answer:6 Difficulty level:4
31.A circle in the $x^{2}+y^{2}-6 x-10 y=2$. What is the diameter of the circle?

Correct answer:12 Difficulty level:4
32.A circle in the $x y$-plane has a center at $\left(\frac{5}{8},-\frac{6}{5}\right)$ and a diameter of $\frac{7}{10}$, Which of the following is an equation of the circle?
A. $\left(x+\frac{5}{8}\right)^{2}+\left(y-\frac{6}{5}\right)^{2}=\frac{49}{100}$
B. $\left(x+\frac{5}{8}\right)^{2}+\left(y-\frac{6}{5}\right)^{2}=\frac{49}{400}$
C. $\left(x-\frac{5}{8}\right)^{2}+\left(y+\frac{6}{5}\right)^{2}=\frac{49}{100}$
D. $\left(x-\frac{5}{8}\right)^{2}+\left(y+\frac{6}{5}\right)^{2}=\frac{49}{400}$

Correct answer:D Difficulty level:4
33.The diameter of a circle graphed in the $x y$-plane has endpoints at $(-23,15)$ and $(1,-55)$. Which of the following is an equation of the circle?
A. $(x+23)^{2}+(y-15)^{2}=1369$
B. $(x+23)^{2}+(y-15)^{2}=5476$
C. $(x+11)^{2}+(y+20)^{2}=5476$
D. $(x+11)^{2}+(y+20)^{2}=1369$

Correct answer:C Difficulty level:4
34.A circle in the $x y$-plane has the equation: $x^{2}+y^{2}-10 x+34 y-527=0$.If the $y$-coordinate of a point on the circle is -38 , what is a possible $x$-coordinate?
Correct answer:25 or -15 Difficulty level:4

## Complex numbers

1. $(-8+4 \mathrm{i})(1-\mathrm{i})$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $-12+4 \mathrm{i}$
B. $-12+12 \mathrm{i}$
C. $-4+12 \mathrm{i}$
D. $-4+4 \mathrm{i}$

Correct answer: C Difficulty level: 2
2. $(4+i)^{2}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $15+8 \mathrm{i}$
B. $15-8 \mathrm{i}$
C. $17+8 \mathrm{i}$
D. $17-8 \mathrm{i}$

Correct answer: A Difficulty level: 2
3. $(8-2 \mathrm{i})(4-2 \mathrm{i})$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $28-24 \mathrm{i}$
B. $28+8 \mathrm{i}$
C. $36-24 \mathrm{i}$
D. $36+8 \mathrm{i}$

Correct answer: A Difficulty level: 2
4. $(5+i)(7-3 i)$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $32+8 \mathrm{i}$
B. $32-8 \mathrm{i}$
C. $38+8 \mathrm{i}$
D. $38-8 \mathrm{i}$

Correct answer: D Difficulty level: 2
5. $i^{4}+4 i^{2}+4$

Which of the following is equivalent to the complex number shown above?

Note: $i=\sqrt{-1}$
A. 1
B. -1
C. $i+4$
D. $i-4$

Correct answer: A Difficulty level: 2
6. $(-3-i)(4-2 i)$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $-14-2 \mathrm{i}$
B. $-14+2 \mathrm{i}$
C. $-10-2 \mathrm{i}$
D. $-10+2 \mathrm{i}$

Correct answer: B Difficulty level: 2
7. $(6+2 i)^{2}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $40+4 i^{2}$
B. $40+24 i$
C. $32+24 i$
D. $32+4 i^{2}$

Correct answer: C Difficulty level: 2
8. $(1+\mathrm{i})(1-\mathrm{i})$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $2-2 \mathrm{i}$
B. 2 i
C. 0
D. 2

Correct answer: D Difficulty level: 2
9. $\mathrm{i}(7-3 \mathrm{i})$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. 4 i
B. 10 i
C. $7 \mathrm{i}-3$
D. $7 \mathrm{i}+3$

Correct answer: D Difficulty level: 2
10. $\frac{i^{2}-16}{i+4}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $\mathrm{i}-4$
B. $i+4$
C. $-\mathrm{i}-4$
D. $-\mathrm{i}+4$

Correct answer: A Difficulty level: 2
11. $(3+i)(2-4 i)$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $2-10 \mathrm{i}$
B. $2-14 \mathrm{i}$
C. $10-10 \mathrm{i}$
D. $10-14 \mathrm{i}$

Correct answer: C Difficulty level: 2
12. $i^{101}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. 1
B. -1
C. $i$
D. $-i$

Correct answer: C Difficulty level: 2
13. $(5-i)^{2}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $24-10 \mathrm{i}$
B. $24+10 \mathrm{i}$
C. $26-10 \mathrm{i}$
D. $26+10 \mathrm{i}$

Correct answer: A Difficulty level: 2
14. $-8\left(7 i-3 i^{2}\right)$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $-80 i$
B. $-56 i-24$
C. $-56+24 i$
D. $-32 i$

Correct answer: B Difficulty level: 3
15. $\frac{3}{2+i}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $2-\mathrm{i}$
B. $2+\mathrm{i}$
C. $\frac{6+3 i}{5}$
D. $\frac{6+3 i}{5}$

Correct answer: D Difficulty level: 3
16. $(3-i)^{3}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $8-26 \mathrm{i}$
B. $18-26 \mathrm{i}$
C. $27-26 \mathrm{i}$
D. $30-26 \mathrm{i}$

Correct answer: B Difficulty level: 3
17. $\left(5-7 i+i^{2}\right)+\left(8 i^{3}+12\right)$

The complex expression above is equivalent to the expression $\mathrm{a}+\mathrm{bi}$ for the integer constants a and $b$. What is the value of $a$ ?
Note: $i=\sqrt{-1}$
A. 16
B. 17
C. 18
D. 19

Correct answer: A Difficulty level: 3
18. $(-3+2 i)\left(1-i^{3}\right)$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $-5-\mathrm{i}$
B. $-5+5 \mathrm{i}$
C. $-1-\mathrm{i}$
D. $-1+5 \mathrm{i}$

Correct answer: A Difficulty level: 3
19. $i^{11}+i^{13}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. -2 i
B. 2 i
C. 0
D. 2

Correct answer: C Difficulty level: 3
20. $\frac{5}{1+3 i}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $\frac{1+3 i}{2}$
B. $\frac{1-3 i}{2}$
C. $\frac{-5(1+3 i)}{8}$
D. $\frac{-5(1-3 i)}{8}$

Correct answer: B Difficulty level: 3
21. $\left(10-8 i^{3}\right)-(6+i)$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $4-7 \mathrm{i}$
B. $4+7 \mathrm{i}$
C. $4+9 \mathrm{i}$
D. $4-9 \mathrm{i}$

Correct answer: B Difficulty level: 3
22. $\frac{1}{1-i}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $2-2 \mathrm{i}$
B. $2+2 \mathrm{i}$
C. $\frac{1-i}{2}$
D. $\frac{1+i}{2}$

Correct answer: D Difficulty level: 3
23. $\frac{2}{1-i}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $1-\mathrm{i}$
B. $1+\mathrm{i}$
C. $2-\mathrm{i}$
D. $2+\mathrm{i}$

Correct answer: B Difficulty level: 3
24. $8 i x=-5$

What is the value of x in the equation above?
Note: $i=\sqrt{-1}$
A. $-\frac{8 i}{5}$
B. $\frac{8 i}{5}$
C. $-\frac{5 i}{8}$
D. $\frac{5 i}{8}$

Correct answer: D Difficulty level: 3
25. $(2-3 i)^{3}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $-46-9 \mathrm{i}$
B. $-26-9 \mathrm{i}$
C. $26-9 \mathrm{i}$
D. $46-9 \mathrm{i}$

Correct answer: A Difficulty level: 3
26. $\left(\frac{1}{2}+i\right)(8-6 i)$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $-2+5 \mathrm{i}$
B. $2+2 \mathrm{i}$
C. $10+5 \mathrm{i}$
D. $14+2 \mathrm{i}$

Correct answer: C Difficulty level: 3
27. $\frac{1}{1-6 i}-\frac{1}{1+6 i}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $\frac{12}{37} i$
B. $-\frac{12}{37} i$
C. $\frac{12}{37}$
D. $-\frac{12}{37}$

Correct answer: A Difficulty level: 3
28. $\left(\frac{2}{3}+\frac{1}{2} i\right)\left(12-\frac{1}{3} i\right)$

The complex expression above is equivalent to the expression $\mathrm{a}+\mathrm{bi}$ for the rational constants a and $b$. What is the value of $b$ ?
Note: $i=\sqrt{-1}$
A. $\mathrm{b}=\frac{1}{6}$
B. $\mathrm{b}=-\frac{1}{6}$
C. $\mathrm{b}=\frac{49}{6}$
D. $\mathrm{b}=\frac{52}{9}$

Correct answer: D Difficulty level: 3
29. $\mathrm{P}(x)=2 x^{2}+3 x-17$

If $x=8-2 i$, what is the value of the polynomial $P$ above?
Note: $i=\sqrt{-1}$
A. $15-2 \mathrm{i}$
B. $23-6 \mathrm{i}$
C. $127-70 \mathrm{i}$
D. $135-62 \mathrm{i}$

Correct answer: C Difficulty level: 3
30. $\left(6+i^{2}\right)(2-2 i)$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $6-8 \mathrm{i}$
B. $8-8 \mathrm{i}$
C. $10-8 \mathrm{i}$
D. $12-8 \mathrm{i}$

Correct answer: B Difficulty level: 3
31. $\frac{3}{i}+\frac{2}{i^{2}}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $3 \mathrm{i}+2$
B. $3 \mathrm{i}-2$
C. $-3 \mathrm{i}+2$
D. $-3 \mathrm{i}-2$

Correct answer: D Difficulty level: 3
32. $\frac{2}{1+i}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $-1+\mathrm{i}$
B. $-1-\mathrm{i}$
C. $1+\mathrm{i}$
D. $1-\mathrm{i}$

Correct answer: D Difficulty level: 4
33. $3 i^{10}+i^{11}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $3+\mathrm{i}$
B. $-3+\mathrm{i}$
C. $3-\mathrm{i}$
D. $-3-\mathrm{i}$

Correct answer: D Difficulty level: 4
34. $P(n)=n^{2}-5 n-7$

What is the value of $\mathrm{P}(-3 \mathrm{i})$ ?
Note: $i=\sqrt{-1}$
A. $-4+15 \mathrm{i}$
B. $-7+12 \mathrm{i}$
C. $-7+24 \mathrm{i}$
D. $-16+15 \mathrm{i}$

Correct answer: D Difficulty level: 4
35. $\sqrt{3} t^{2}+5 t+\sqrt{27}=0$

Which of the following is a solution to the equation above?
Note: $i=\sqrt{-1}$
A. $\mathrm{t}=\frac{-4 \sqrt{11} i}{6}$
B. $\mathrm{t}=\frac{-3 \sqrt{33} i}{6}$
C. $\mathrm{t}=\frac{-5+\sqrt{11 i}}{6}$
D. $\mathrm{t}=\frac{-5 \sqrt{3}+\sqrt{33} i}{6}$

Correct answer: D Difficulty level: 4
36. $29=3(x+7)^{2}+41$

Which of the following is a solution to the equation above?
Note: $i=\sqrt{-1}$
A. $x=-7+2 i$
B. $x=-42-12 i$
C. $x=-\frac{7}{6}+\frac{\sqrt{443}}{6} i$
D. $x=-7-\frac{\sqrt{123}}{3} i$

Correct answer: A Difficulty level: 4
37. $(8-2 i)^{2}(8+2 i)$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. 60
B. 68
C. $480-120 \mathrm{i}$
D. $544-136 \mathrm{i}$

Correct answer: D Difficulty level: 4
38. $\frac{\sqrt{54 i}{ }^{41}}{\sqrt{27} i^{101}}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $-\sqrt{2} i$
B. $-\sqrt{2}$
C. $\sqrt{2}$
D. $\sqrt{2} i$

Correct answer: C Difficulty level: 4
39. $\frac{2}{2-i}-\frac{2}{2+i}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $\frac{4 i}{5}$
B. $\frac{-4 i}{5}$
C. $\frac{2 i}{3}$
D. $-\frac{2 i}{3}$

Correct answer: A Difficulty level: 4
40. $\frac{1+2 i}{1-2 i} \div \frac{1-2 i}{1+2 i}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. 1
B. -1
C. $-\frac{7}{25}+\frac{24}{25} i$
D. $-\frac{7}{25}-\frac{24}{25} i$

Correct answer: D Difficulty level: 4
41. $i^{3}+i^{2}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. -1
B. -2
C. $-1+\mathrm{i}$
D. $-1-\mathrm{i}$

Correct answer: D Difficulty level: 4
42. $m^{2}+6 m+10=0$

Which of the following are solutions to the equation above?
I. $-3+\mathrm{i}$
II. -3-i
III. $3+$ i

Note: $i=\sqrt{-1}$
A. I only
B. I and II only
C. I and III only
D. I, II, and III

Correct answer: B Difficulty level: 4
43. $704 i^{1776}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. 704
B. -704
C. 704 i
D. -704 i

Correct answer: A Difficulty level: 4
44. $\frac{1}{2+5 i}-\frac{4+3 i}{3-i}$

Which of the following is equivalent to the complex number shown above?

Note: $i=\sqrt{-1}$
A. $\frac{10+26 i}{(2+5 i)(3-i)}$
B. $\frac{10-26 i}{(2+5 i)(3-i)}$
C. $\frac{10+27 i}{(2+5 i)(3-i)}$
D. $\frac{10-27 i}{(2+5 i)(3-i)}$

Correct answer: D Difficulty level: 4
45. $\frac{5+7 i}{6-3 i}$

Which of the following is equivalent to the complex number shown above?
Note: $i=\sqrt{-1}$
A. $\frac{9+57 i}{45}$
B. $\frac{9+57 i}{3}$
C. $\frac{51+57 i}{45}$
D. $\frac{51+57 i}{3}$

Correct answer: A Difficulty level: 4
46. $\frac{9+7 i^{18}}{4-i}$

The complex expression above is equivalent to the expression $\mathrm{a}+\mathrm{bi}$ for the rational constants a and $b$. What is the value of $b$ ?
Note: $i=\sqrt{-1}$
A. $\mathrm{b}=\frac{2}{15}$
B. $\mathrm{b}=\frac{2}{17}$
C. $b=-1$
D. $b=-7$

Correct answer: B Difficulty level: 4
47. $5-i+(11-i) z=40+18 i$

What is the value of z in the equation above?
Note: $i=\sqrt{-1}$
A. $\mathrm{z}=-19+24 \mathrm{i}$
B. $\mathrm{z}=24+20 \mathrm{i}$
C. $z=3+2 i$
D. $z=3.2+145 \mathrm{i}$

Correct answer: C Difficulty level: 4
48. $2 i+4 h-14=2 i h$

What is the value of h in the equation above?
Note: $i=\sqrt{-1}$
A. $h=3+i$
B. $h=\frac{7}{2}$
C. $h=7-i$
D. $h=\frac{8}{3}$

Correct answer: A Difficulty level: 4

