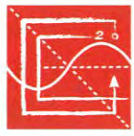


NCEES
advancing licensure for engineers and surveyors

FE

civil

practice exam

CONTENTS

About NCEES

NCEES is a nonprofit organization made up of the U.S. engineering and surveying licensing boards in all 50 states, U.S. territories, and the District of Columbia. We develop and score the exams used for engineering and surveying licensure in the United States. NCEES also promotes professional mobility through its services for licensees and its member boards.

Engineering licensure in the United States is regulated by licensing boards in each state and territory. These boards set and maintain the standards that protect the public they serve. As a result, licensing requirements and procedures vary by jurisdiction, so stay in touch with your board (ncees.org/licensing-boards).

Exam Format

The FE exam contains 110 questions and is administered year-round via computer at approved Pearson VUE test centers. A 6-hour appointment time includes a tutorial, the exam, and a break. You'll have 5 hours and 20 minutes to complete the actual exam.

Beginning July 1, 2017, in addition to traditional multiple-choice questions with one correct answer, the FE exam will use common alternative item types such as

- Multiple correct options—allows multiple choices to be correct
- Point and click—requires examinees to click on part of a graphic to answer
- Drag and drop—requires examinees to click on and drag items to match, sort, rank, or label
- Fill in the blank—provides a space for examinees to enter a response to the question

To familiarize yourself with the format, style, and navigation of a computer-based exam, view the demo on ncees.org/ExamPrep.

Examinee Guide

The *NCEES Examinee Guide* is the official guide to policies and procedures for all NCEES exams. During exam registration and again on exam day, examinees must agree to abide by the conditions in the *Examinee Guide*, which includes the CBT Examinee Rules and Agreement. You can download the *Examinee Guide* at ncees.org/exams. It is your responsibility to make sure you have the current version.

Scoring and reporting

Exam results for computer-based exams are typically available 7–10 days after you take the exam. You will receive an email notification from NCEES with instructions to view your results in your MyNCEES account. All results are reported as pass or fail.

Updates on exam content and procedures

Visit us at **ncees.org/exams** for updates on everything exam-related, including specifications, exam-day policies, scoring, and corrections to published exam preparation materials. This is also where you will register for the exam and find additional steps you should follow in your state to be approved for the exam.

EXAM SPECIFICATIONS

Fundamentals of Engineering (FE)
CIVIL CBT Exam Specifications

Effective Beginning with the January 2014 Examinations

- The FE exam is a computer-based test (CBT). It is closed book with an electronic reference.
- Examinees have 6 hours to complete the exam, which contains 110 multiple-choice questions. The 6-hour time also includes a tutorial and an optional scheduled break.
- The FE exam uses both the International System of Units (SI) and the U.S. Customary System (USCS).

Knowledge	Number of Questions
1. Mathematics A. Analytic geometry B. Calculus C. Roots of equations D. Vector analysis	7–11
2. Probability and Statistics A. Measures of central tendencies and dispersions (e.g., mean, mode, standard deviation) B. Estimation for a single mean (e.g., point, confidence intervals) C. Regression and curve fitting D. Expected value (weighted average) in decision making	4–6
3. Computational Tools A. Spreadsheet computations B. Structured programming (e.g., if-then, loops, macros)	4–6
4. Ethics and Professional Practice A. Codes of ethics (professional and technical societies) B. Professional liability C. Licensure D. Sustainability and sustainable design E. Professional skills (e.g., public policy, management, and business) F. Contracts and contract law	4–6
5. Engineering Economics A. Discounted cash flow (e.g., equivalence, PW, equivalent annual worth, FW, rate of return) B. Cost (e.g., incremental, average, sunk, estimating) C. Analyses (e.g., breakeven, benefit-cost, life cycle) D. Uncertainty (e.g., expected value and risk)	4–6

6. **Statics** — **7–11**
   A. Resultants of force systems
   B. Equivalent force systems
   C. Equilibrium of rigid bodies
   D. Frames and trusses
   E. Centroid of area
   F. Area moments of inertia
   G. Static friction

7. **Dynamics** — **4–6**
   A. Kinematics (e.g., particles and rigid bodies)
   B. Mass moments of inertia
   C. Force acceleration (e.g., particles and rigid bodies)
   D. Impulse momentum (e.g., particles and rigid bodies)
   E. Work, energy, and power (e.g., particles and rigid bodies)

8. **Mechanics of Materials** — **7–11**
   A. Shear and moment diagrams
   B. Stresses and strains (e.g., axial, torsion, bending, shear, thermal)
   C. Deformations (e.g., axial, torsion, bending, thermal)
   D. Combined stresses
   E. Principal stresses
   F. Mohr's circle
   G. Column analysis (e.g., buckling, boundary conditions)
   H. Composite sections
   I. Elastic and plastic deformations
   J. Stress-strain diagrams

9. **Materials** — **4–6**
   A. Mix design (e.g., concrete and asphalt)
   B. Test methods and specifications (e.g., steel, concrete, aggregates, asphalt, wood)
   C. Physical and mechanical properties of concrete, ferrous and nonferrous metals, masonry, wood, engineered materials (e.g., FRP, laminated lumber, wood/plastic composites), and asphalt

10. **Fluid Mechanics** — **4–6**
    A. Flow measurement
    B. Fluid properties
    C. Fluid statics
    D. Energy, impulse, and momentum equations

11. Hydraulics and Hydrologic Systems — **8–12**

A. Basic hydrology (e.g., infiltration, rainfall, runoff, detention, flood flows, watersheds)
B. Basic hydraulics (e.g., Manning equation, Bernoulli theorem, open-channel flow, pipe flow)
C. Pumping systems (water and wastewater)
D. Water distribution systems
E. Reservoirs (e.g., dams, routing, spillways)
F. Groundwater (e.g., flow, wells, drawdown)
G. Storm sewer collection systems

12. Structural Analysis — **6–9**

A. Analysis of forces in statically determinant beams, trusses, and frames
B. Deflection of statically determinant beams, trusses, and frames
C. Structural determinacy and stability analysis of beams, trusses, and frames
D. Loads and load paths (e.g., dead, live, lateral, influence lines and moving loads, tributary areas)
E. Elementary statically indeterminate structures

13. Structural Design — **6–9**

A. Design of steel components (e.g., codes and design philosophies, beams, columns, beam-columns, tension members, connections)
B. Design of reinforced concrete components (e.g., codes and design philosophies, beams, slabs, columns, walls, footings)

14. Geotechnical Engineering — **9–14**

A. Geology
B. Index properties and soil classifications
C. Phase relations (air-water-solid)
D. Laboratory and field tests
E. Effective stress (buoyancy)
F. Stability of retaining walls (e.g., active pressure/passive pressure)
G. Shear strength
H. Bearing capacity (cohesive and noncohesive)
I. Foundation types (e.g., spread footings, deep foundations, wall footings, mats)
J. Consolidation and differential settlement
K. Seepage/flow nets
L. Slope stability (e.g., fills, embankments, cuts, dams)
M. Soil stabilization (e.g., chemical additives, geosynthetics)
N. Drainage systems
O. Erosion control

15. **Transportation Engineering** **8–12**
   A. Geometric design of streets and highways
   B. Geometric design of intersections
   C. Pavement system design (e.g., thickness, subgrade, drainage, rehabilitation)
   D. Traffic safety
   E. Traffic capacity
   F. Traffic flow theory
   G. Traffic control devices
   H. Transportation planning (e.g., travel forecast modeling)

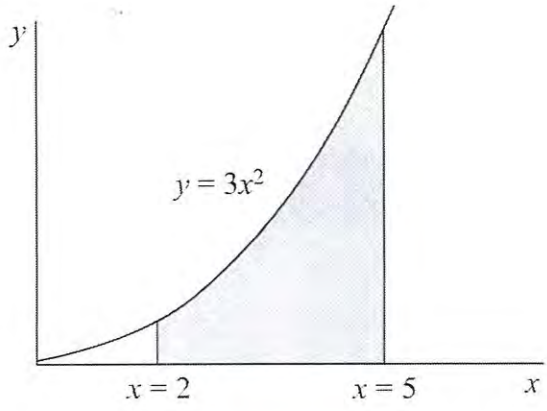
16. **Environmental Engineering** **6–9**
   A. Water quality (ground and surface)
   B. Basic tests (e.g., water, wastewater, air)
   C. Environmental regulations
   D. Water supply and treatment
   E. Wastewater collection and treatment

17. **Construction** **4–6**
   A. Construction documents
   B. Procurement methods (e.g., competitive bid, qualifications-based)
   C. Project delivery methods (e.g., design-bid-build, design build, construction management, multiple prime)
   D. Construction operations and methods (e.g., lifting, rigging, dewatering and pumping, equipment production, productivity analysis and improvement, temporary erosion control)
   E. Project scheduling (e.g., CPM, allocation of resources)
   F. Project management (e.g., owner/contractor/client relations)
   G. Construction safety
   H. Construction estimating

18. **Surveying** **4–6**
   A. Angles, distances, and trigonometry
   B. Area computations
   C. Earthwork and volume computations
   D. Closure
   E. Coordinate systems (e.g., state plane, latitude/longitude)
   F. Leveling (e.g., differential, elevations, percent grades)

PRACTICE EXAM

1. The area of the shaded portion of the figure shown below is most nearly:



- ○ A. 18
- ○ B. 39
- ○ C. 117
- ○ D. 133

2. The indefinite integral of $x^3 - x + 1$ is:

- ○ A. $3x^2 - 1 + C$
- ○ B. $\frac{x^4}{3} - \frac{x^2}{2} + 1 + C$
- ○ C. $\frac{x^4}{3} - \frac{x^2}{2} + 1$
- ○ D. $\frac{x^4}{4} - \frac{x^2}{2} + x + C$

3. The roots of $F = \dfrac{x^3 + 6x^2 + 11x + 6}{x + 1}$ are most nearly:

- A. $-1, -2, -3$
- B. $2, -3$
- C. $-2, -3$
- D. $2, 3$

4. The equation of a sphere with its center at (0, 1, −2) and a radius of 9 is:

- A. $x^2 + (y - 1)^2 + (z + 2)^2 = 81$
- B. $x^2 + (y + 1)^2 + (z - 2)^2 = 81$
- C. $(x + 1)^2 + (y + 1)^2 + (z + 2)^2 = 81$
- D. $(x + 1)^2 + (y + 1)^2 + (z + 2)^2 = 9$

5. The term $\dfrac{(1 - i)^2}{(1 + i)^2}$, where $i = \sqrt{-1}$, is most nearly:

- A. -1
- B. $-1 + i$
- C. 0
- D. $1 + i$

6. Which of the following is a unit vector perpendicular to the plane determined by the vectors $\mathbf{A} = 2\mathbf{i} + 4\mathbf{j}$ and $\mathbf{B} = \mathbf{i} + \mathbf{j} - \mathbf{k}$?

- ○ A. $-2\mathbf{i} + \mathbf{j} - \mathbf{k}$
- ○ B. $\frac{1}{\sqrt{5}}(\mathbf{i} + 2\mathbf{j})$
- ○ C. $\frac{1}{\sqrt{6}}(-2\mathbf{i} + \mathbf{j} - \mathbf{k})$
- ○ D. $\frac{1}{\sqrt{6}}(-2\mathbf{i} - \mathbf{j} - \mathbf{k})$

7. The following data have been collected:

Test	Average Score
1	85
2	87
3	95
4	90
5	85
6	88
7	90
8	90
9	91

Which of the following statements is true?

- ○ A. The median and the mode are equal.
- ○ B. The mean and the median are equal.
- ○ C. The mean and the mode are equal.
- ○ D. The mean is larger than both the mode and the median.

NEXT→

8. You have a fair coin that you toss ten times. The probability of getting exactly four heads in ten tosses is most nearly:

- A. 0.1
- B. 0.2
- C. 0.4
- D. 0.5

9. You throw two 6-sided fair dice. The probability that the sum will be less than 12 is most nearly:

- A. 0.028
- B. 0.083
- C. 0.333
- D. 0.972

NEXT→

10. The only point of inflection on the curve representing the equation $y = x^3 + x^2 - 3$ is at:

- ○ A. $x = -\frac{2}{3}$
- ○ B. $x = -\frac{1}{3}$
- ○ C. $x = 0$
- ○ D. $x = \frac{1}{3}$

11. A spreadsheet display shows the following values in Column A:

	A	B
1	–2	
2	–1	
3	0	
4	1	
5	2	

Cell B1 contains the formula $A1^3 + A$1^2 – 3. The formula in Cell B1 is copied down in Column B with automatic cell referencing. The formula in Cell B5 will be:

- ○ A. $A1^3 + A$5^2 – 3
- ○ B. A5^3 + B$1^2 – 3
- ○ C. $A5^3 + A$1^2 – 3
- ○ D. A5^3 + A5^2 – 3

NEXT→

12. In a spreadsheet, the number in Cell A4 is set to 6. Then A5 is set to A4 + A4. This formula is copied into Cells A6 and A7 with automatic cell referencing. The number shown in Cell A7 is _____.

Answer to the nearest integer.

13. The following segment of pseudocode describes a segment of a computer program:

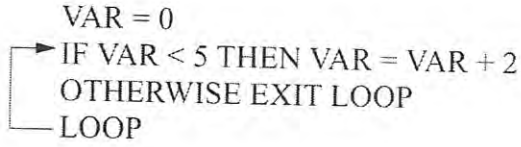
```
Set A = 17
Set K = 2
While K ≤ 4
   A = A/K
   K = K + 1
End While
Print A
```

The value of A that is printed is most nearly:

- ○ A. 0.71
- ○ B. 2.83
- ○ C. 4.25
- ○ D. 408

NEXT→

14. The flowchart for a computer program contains the following segment:



What is the value of VAR at the conclusion of this routine?

- O A. 0
- O B. 2
- O C. 4
- O D. 6

15. According to the *Model Rules*, Section 240.15, Rules of Professional Conduct, licensed professional engineers are obligated to:

- O A. ensure that design documents and surveys are reviewed by a panel of licensed engineers prior to affixing a seal of approval
- O B. express public opinions under the direction of an employer or client regardless of knowledge of subject matter
- O C. practice by performing services only in the areas of their competence and in accordance with the current standards of technical competence
- O D. offer, give, or solicit services directly or indirectly in order to secure work or other valuable or political considerations

NEXT→

16. As a professional engineer originally licensed 30 years ago, you are asked to evaluate a newly developed computerized control system for a public transportation system. The owner requires a currently licensed engineer to evaluate the system. You may accept this project if:

Select **all** that apply.

- ☐ A. you are competent in the area of computerized control systems
- ☐ B. your professional engineering license has lapsed, but you have two FE interns working for you
- ☐ C. you took a transportation course in college
- ☐ D. you have regularly attended meetings of a professional engineering society
- ☐ E. you have another licensed engineer work for you who is competent in this area, and he/she will conduct all related work and stamp the related design

17. An engineer testifying as an expert witness in a product liability case should:

- ○ A. answer as briefly as possible only those questions posed by the attorneys
- ○ B. provide an evaluation of the character of the defendant
- ○ C. provide a complete and objective analysis within his or her area of competence
- ○ D. provide information on the professional background of the defendant

18. A lien is a:

- ○ A. claim on property for payment of a debt
- ○ B. requirement that a contractor secure a performance bond for a project
- ○ C. requirement that a contractor secure a payment bond for a project
- ○ D. claim for damages for lack of specific performance

NEXT→

19. A company borrows $100,000 today at 12% nominal annual interest. The monthly payment of a 5-yr loan is most nearly:

- O A. $1,667
- O B. $2,200
- O C. $3,100
- O D. $12,000

20. You must choose between four pieces of comparable equipment based on the costs and salvage values given below. All four pieces have a life of 8 years.

Parameter	Equipment			
	A	B	C	D
First cost	$25,000	$35,000	$20,000	$40,000
Annual costs	$8,000	$6,000	$9,000	$5,000
Salvage value	$2,500	$3,500	$2,000	$4,000

The discount rate is 12%. Ignore taxes. The two most preferable projects and the approximate difference between their present worth values based on least cost are:

- O A. A and C, $170
- O B. B and D, $170
- O C. A and C, $234
- O D. B and D, $234

NEXT→

21. A tractor cost $7,500. After 10 years it has a salvage value of $5,000. Maintenance costs are $500 per year. If the interest rate is 10%, the equivalent uniform annual cost is most nearly:

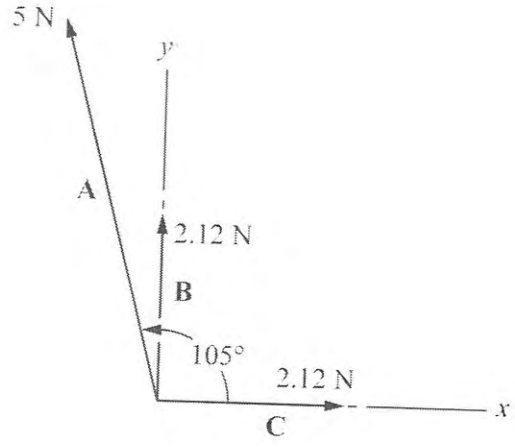
- A. $500
- B. $750
- C. $1,400
- D. $2,000

22. A company can manufacture a product using hand tools. Tools will cost $1,000, and the manufacturing cost per unit will be $1.50. As an alternative, an automated system will cost $15,000 with a manufacturing cost per unit of $0.50. With an anticipated annual volume of 5,000 units and neglecting interest, the break-even point (years) is most nearly:

- A. 2.0
- B. 2.8
- C. 3.6
- D. 15.0

NEXT→

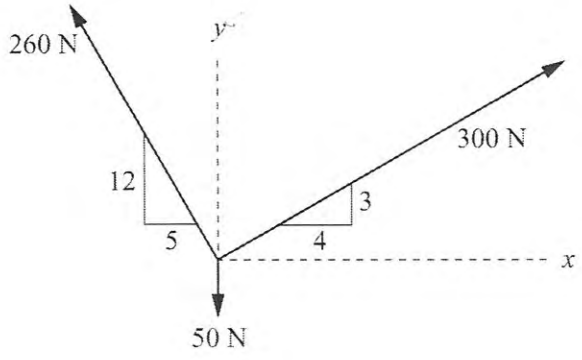
23. The magnitude (N) of the resultant of the three coplanar forces, A, B, and C, is most nearly:



- ○ A. 7.0
- ○ B. 7.8
- ○ C. 9.2
- ○ D. 10.3

NEXT→

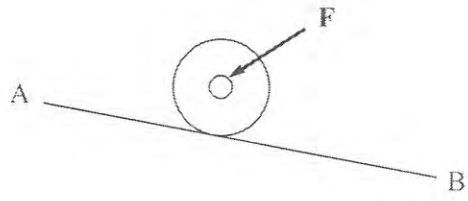
14. Three forces act as shown below. The magnitude of the resultant of the three forces (N) is most nearly:

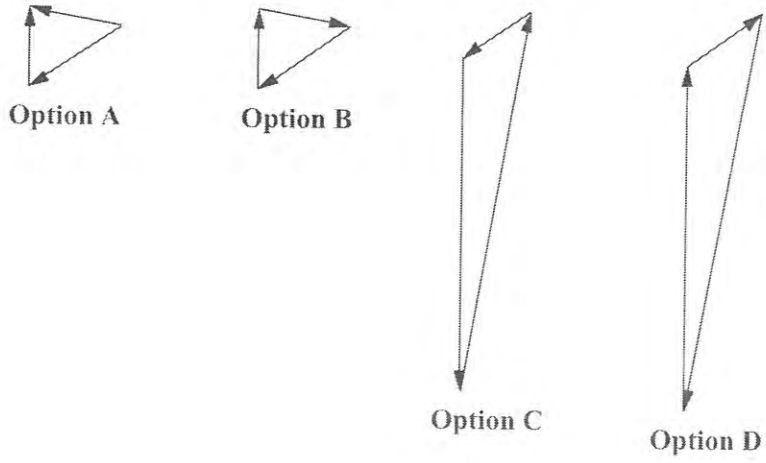


- A. 140
- B. 191
- C. 370
- D. 396

NEXT→

25. A heavy roller is held in equilibrium on a frictionless Plane AB by the force **F**, as shown. Whic diagram correctly shows a vector polygon of the forces acting on the roller?

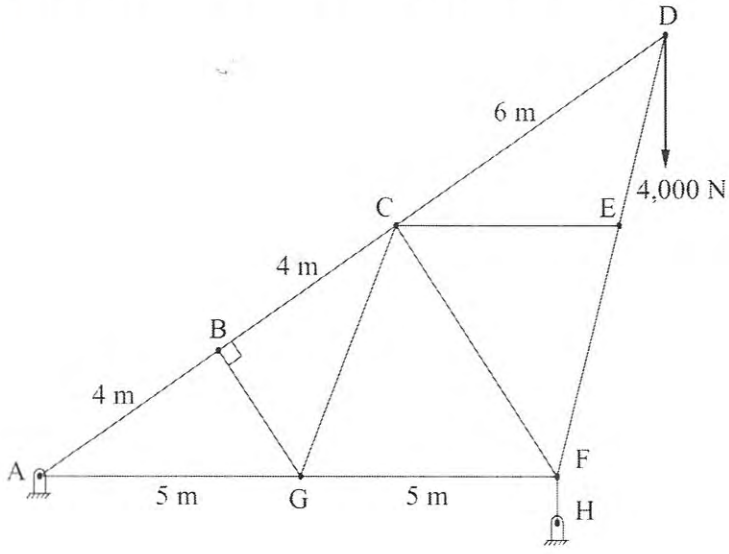




- ○ A. Option A
- ○ B. Option B
- ○ C. Option C
- ○ D. Option D

NEXT→

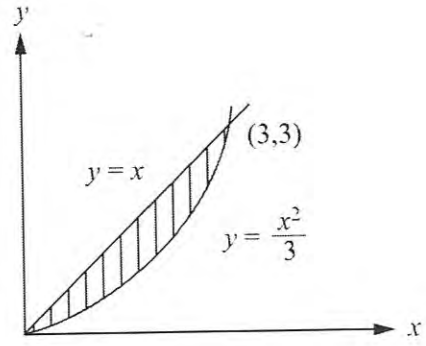
16. The figure below shows a simple truss. The zero-force members in the truss are:



- A. BG, CG, CF, CE
- B. BG, CE
- C. CG, CF
- D. CF

NEXT→

27. Consider the following graph:



Which of the following expressions gives the distance from the y-axis to the centroid of the shaded area?

○ A. $\dfrac{\int_0^3 \frac{1}{3}x^3\,dx}{\int_0^3 \left(x+\frac{1}{3}x^2\right)dx}$

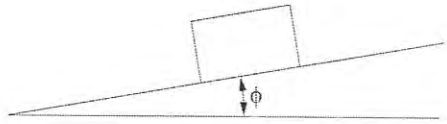
○ B. $\dfrac{\int_0^3 \left(x^2-\frac{1}{3}x^3\right)dx}{\int_0^3 \left(x-\frac{1}{3}x^2\right)dx}$

○ C. $\dfrac{\int_0^3 \left(x-\frac{1}{3}x^2\right)dx}{\int_0^3 \left(x-\frac{1}{3}x^2\right)dx}$

○ D. $\dfrac{\int_0^3 \left(\frac{1}{2}x^2+\frac{1}{3}x^3\right)dx}{\int_0^3 \left(x-\frac{1}{3}x^2\right)dx}$

NEXT→

18. In the figure below, the coefficient of static friction between the block and the inclined plane is 0.25. The block is in equilibrium. As the inclined plane is raised, the block will begin to slide when:



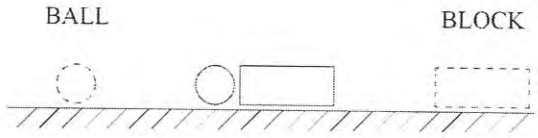
- A. $\sin \phi = 1.0$
- B. $\cos \phi = 1.0$
- C. $\cos \phi = 0.25$
- D. $\tan \phi = 0.25$

19. A boat accelerates at a constant rate of 12 ft/sec^2. The boat travels 140 ft while its speed changes to 60 ft/sec. The initial velocity (ft/sec) was most nearly:

- A. 3.7
- B. 5.0
- C. 15.5
- D. 31.0

NEXT→

30. A ball strikes a stationary block with a velocity of 10 ft/sec. The velocity of the block after impact is 4 ft/sec. The mass of the block is twice the mass of the ball. The coefficient of restitution is most nearly:



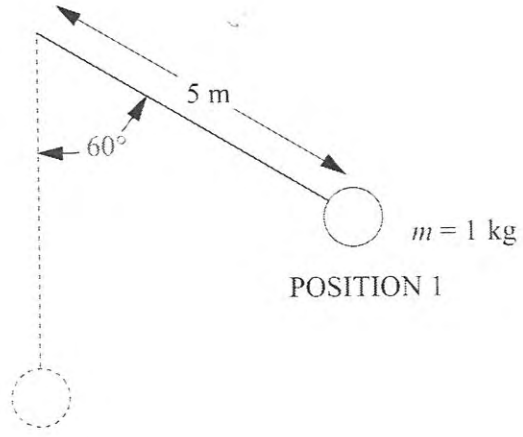
- O A. 0.10
- O B. 0.20
- O C. 0.25
- O D. 0.40

31. During impact of two objects, which of the following is true?

- O A. Energy is never conserved.
- O B. Energy is always conserved.
- O C. Momentum is never conserved.
- O D. Momentum is always conserved.

NEXT→

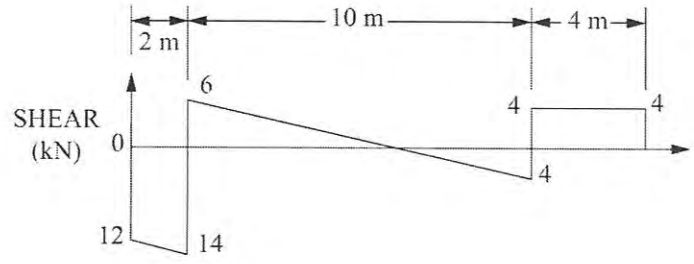
If a pendulum is released from rest at Position 1, the velocity (m/s) of the mass at Position 2 is most nearly:



- A. 5.0
- B. 7.0
- C. 9.8
- D. 12.7

NEXT→

33. The shear diagram for a particular beam is shown below. All lines in the diagram are straight. The bending moment at each end of the beam is zero, and there are no concentrated couples along the beam. The maximum magnitude of the bending moment (kN·m) in the beam is most nearly:



- O A. 8
- O B. 16
- O C. 18
- O D. 26

NEXT→

34. The pressure gage in an air cylinder reads 1,680 kPa. The cylinder is constructed of a 12-mm rolled-steel plate with an internal diameter of 700 mm. The tangential stress (MPa) inside the tank is most nearly:

- A. 25
- B. 50
- C. 77
- D. 100

35. A shaft of wood is to be used in a certain process. If the allowable shearing stress parallel to the grain of the wood is 840 kN/m^2, the torque (N·m) transmitted by a 200-mm-diameter shaft with the grain parallel to the neutral axis is most nearly:

- A. 500
- B. 1,200
- C. 1,320
- D. 1,500

NEXT→

36. The piston of a steam engine is 50 cm in diameter, and the maximum steam gage pressure is 1.4 MPa. If the design stress for the piston rod is 68 MPa, its cross-sectional area (m^2) should be most nearly:

- ○ A. 40.4×10^{-4}
- ○ B. 98.8×10^{-4}
- ○ C. 228.0×10^{-4}
- ○ D. 323.0×10^{-4}

37. Which of the following is true when a circular shaft is subjected to torsion only?

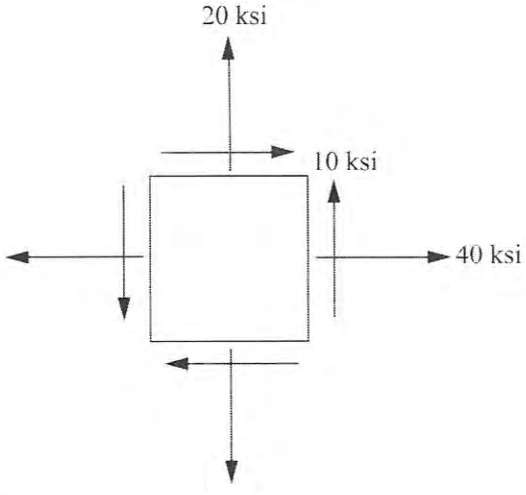
- ○ A. Maximum shear stress occurs at the outermost fibers.
- ○ B. Maximum shear stress occurs at the center of the shaft.
- ○ C. Constant shear stress occurs throughout the shaft.
- ○ D. No shear stress is present throughout the shaft.

NEXT→

38. A 1-ft rod with a diameter of 0.5 in. is subjected to a tensile force of 1,300 lb and has an elongation of 0.009 in. The modulus of elasticity (ksi) of the material is most nearly:

- A. 740
- B. 884
- C. 8,840
- D. 10,000

39. The maximum inplane shear stress (ksi) in the element shown below is most nearly:



- A. 10
- B. 14.1
- C. 44.1
- D. 316

NEXT→

40. The Euler formula for columns deals with:

- ○ A. relatively short columns
- ○ B. shear stress
- ○ C. tensile stress
- ○ D. elastic buckling

41. Ready-mixed concrete being delivered to a jobsite is found to have a slump less than specified. Which of the following is the most appropriate corrective action?

- ○ A. Decrease the amount of water in the mix before the truck leaves the ready-mix plant.
- ○ B. Increase the water to the mix in the truck at the jobsite before the concrete is poured.
- ○ C. Add an admixture to the mix in the truck at the jobsite before the concrete is poured.
- ○ D. Increase the rotation speed of the mixing drum while the truck is in transit to the jobsite.

NEXT→

42. The following preliminary concrete mix has been designed assuming that the aggregates are in oven-dry condition.

Water = 305 lb/yd^3
Cement = 693 lb/yd^3
Coarse aggregate (SSD) = 1,674 lb/yd^3
Fine aggregate (SSD) = 1,100 lb/yd^3

The properties of the aggregates are:

Property	Coarse Aggregate	Fine Aggregate
Absorption (moisture content at SSD)	0.5%	0.7%
Moisture content as used in mix	2.0%	6.0%

The amount of water (lb/yd^3) that would be used in the final mix is most nearly:

- A. 206
- B. 222
- C. 305
- D. 388

43. The test that measures the energy required to fracture a specimen at a given temperature is the:

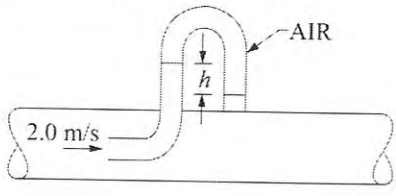
- A. Brinell Test
- B. Rockwell Test
- C. Endurance Test
- D. Charpy Test

NEXT→

44. In general, a metal with high hardness will also have:

- ○ A. good formability
- ○ B. high impact strength
- ○ C. high electrical conductivity
- ○ D. high yield strength

45. The pitot tube shown below is placed at a point where the velocity is 2.0 m/s. The specific gravity of the fluid is 2.0, and the upper portion of the manometer contains air. The reading h (m) on the manometer is most nearly:



- ○ A. 20.0
- ○ B. 10.0
- ○ C. 0.40
- ○ D. 0.20

NEXT→

46. If the standard density of water is 1,000 kg/m^3, a fluid having a specific gravity of 1.263 and an absolute dynamic viscosity of 1.5 kg/(m·s) has a kinematic viscosity (m^2/s) of most nearly:

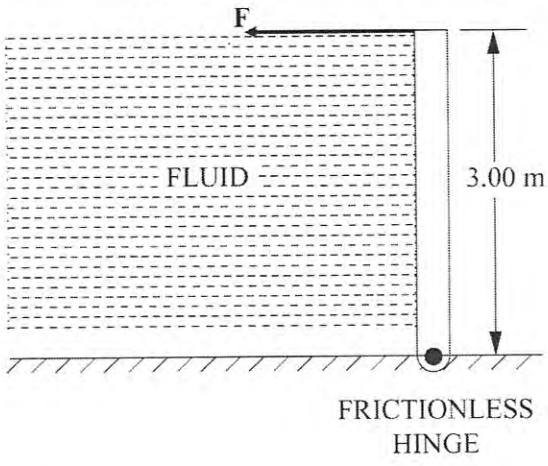
- A. 1.19×10^{-3}
- B. 1.50×10^{-3}
- C. 1.89×10^{-3}
- D. 528

47. Archimedes' principle states that:

- A. the sum of the pressure, velocity, and elevation heads is constant
- B. flow passing two points in a stream is equal at each point
- C. the buoyant force on a body is equal to the volume displaced by the body
- D. a floating body displaces a weight of fluid equal to its own weight

NEXT→

48. The rectangular homogeneous gate shown below is 3.00 m high × 1.00 m wide and has a frictionless hinge at the bottom. If the fluid on the left side of the gate has a density of 1,600 kg/m^3, the magnitude of the force **F** (kN) required to keep the gate closed is most nearly:



- ○ A. 0
- ○ B. 22
- ○ C. 24
- ○ D. 220

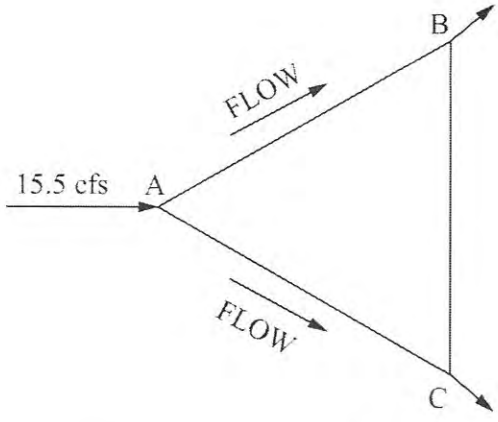
49. A 20-acre parcel of land has a rainfall intensity of 1.5 in./hr and a rational method runoff coefficient C. of 0.10. The flow rate (cfs) for this site is most nearly:

- ○ A. 3.0
- ○ B. 5.0
- ○ C. 7.5
- ○ D. 9.0

NEXT→

A flow of 15.5 cfs enters the pipe system at A as shown, and exits at B and C. Pipe data are given in the following table.

Pipe	f	Length (ft)	Diameter (in.)	Velocity (fps)
AB	0.03	200	24	2.0
AC	0.03	200	36	1.3
CB	0.03	200	48	



Assume the pipes are all at the same elevation. The head loss (ft) in Pipe CB is most nearly:

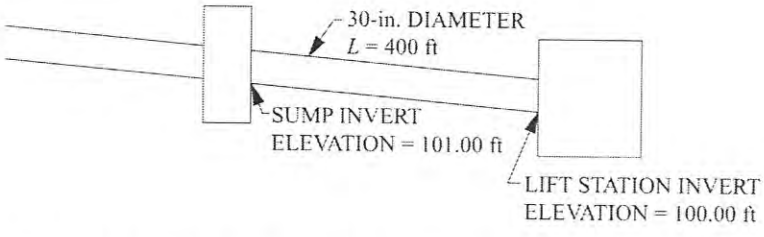
- A. 0.05
- B. 0.13
- C. 0.18
- D. 0.23

NEXT→

51. Waste activated sludge can be described as a Newtonian fluid with a kinematic viscosity of 20×10^{-5} ft^2/sec. At the same temperature, the kinematic viscosity, v, of water is 10^{-5} ft^2/sec. The relative roughness of the piping system is 0.001. The pressure drop for flow of water at a Reynolds number of 10^7 in this piping system has been determined to be 1.0 psi. If waste activated sludge flows at the same velocity through the piping system, the pressure drop (psi) is most nearly:

- O A. 1.0
- O B. 2.0
- O C. 3.0
- O D. 4.0

52. A sanitary sewer delivers flow from a sump to a lift station as shown in the figure below. The sewer length is 400 ft, and the diameter is 30 in. The sewer is made of concrete (Manning's roughness coefficient, $n = 0.013$, and is constant with depth).



For full pipe flow with water surface elevations in the upstream sewer sump and lift station wet well of 105.00 and 103.50 ft, respectively, the discharge (cfs) is most nearly:

- O A. 46.1
- O B. 25.1
- O C. 13.8
- O D. 5.1

NEXT→

33. A pump station delivers wastewater from a sump at an elevation of 78 ft to a maintenance hole with a water surface elevation of 112 ft. The static head (ft) for this pump is most nearly:

- A. 17
- B. 34
- C. 44
- D. 78

34. The pressure in a water main at ground level is 85 psi. A developer plans to build a six-story building. The height between floors will be 12 ft. Neglecting friction losses, the pressure (psi) on the sixth floor will be most nearly:

- A. 31
- B. 54
- C. 85
- D. 117

55. Two tanks are connected by a 9,000-ft length of 12-in.-I.D. PVC pipe. The appropriate value for the Hazen-Williams coefficient, C, is 150. Water at 60°F is flowing through the pipe at a velocity of 10 ft/sec. The tanks are open to the atmosphere. Entrance, exit, and minor losses are negligible. The difference in water surface elevation (ft) between the two tanks is most nearly:

- O A. 81
- O B. 167
- O C. 181
- O D. 447

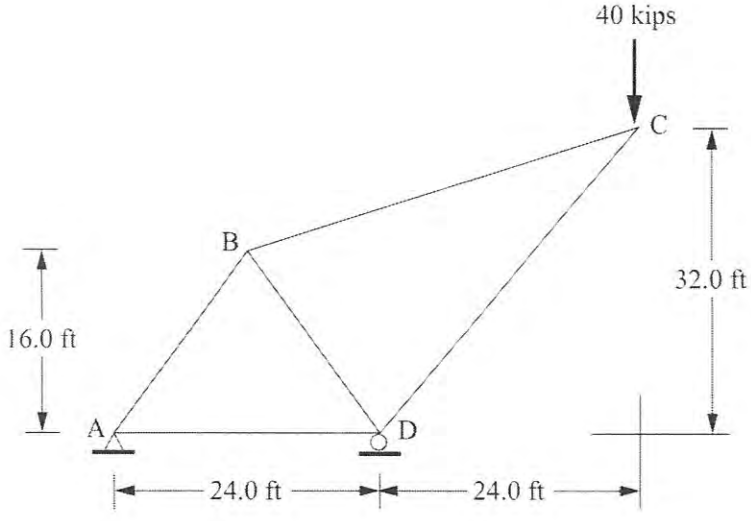
56. In an area with a composite runoff coefficient of 0.65, the surface runoff flows toward a street from the land on both sides. The watershed area extends to 100 ft on each side of the street centerline. The street has curb-and-gutter, and there is a curb inlet (or basin) on both sides of the street. The capacity of the curb inlet to pick up runoff from the gutter is 10 cfs (any more than this will just run past the opening). City policy is to design the street drainage system to accommodate a 6.8-in./hr rainfall. The distance (ft) between the inlets along the street should be most nearly:

- O A. 980
- O B. 640
- O C. 490
- O D. 230

NEXT→

87. The 40-kip vertical load at Joint C in the steel truss shown below produces the forces given in the accompanying table. The cross-sectional area of each member is 4.0 in^2, and the length of each member is given in the table. The elastic modulus of steel is 29,000 ksi. The downward vertical displacement (in.) of Joint C is most nearly:

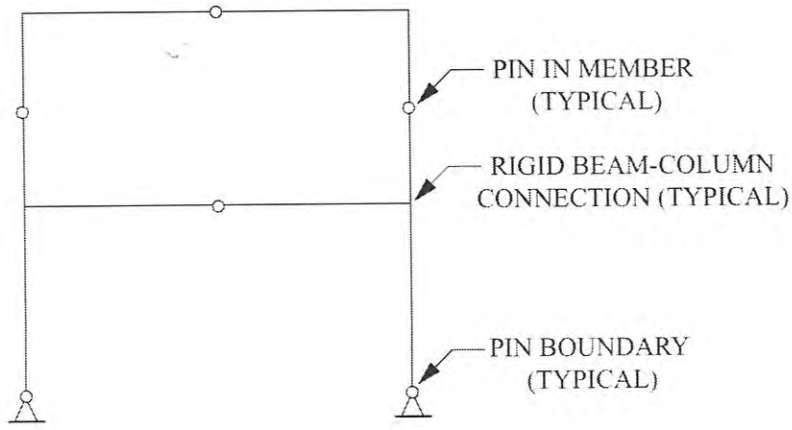
Member	Force, F (kips)	Length, L (in.)	$\frac{FL}{AE}$
AB	50.0	240	0.1034
BC	49.2	473	0.2008
CD	–75.0	480	–0.3103
AD	–30.0	288	–0.0745
BD	–25.0	240	–0.0517



- A. 1.046
- B. 0.294
- C. 0.132
- D. 0.102

NEXT→

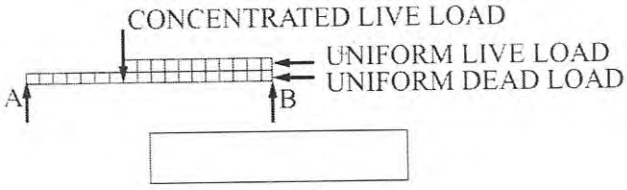
58. The frame in the figure below is:

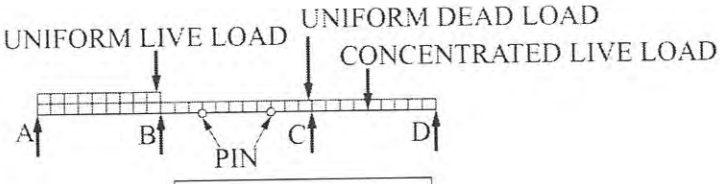


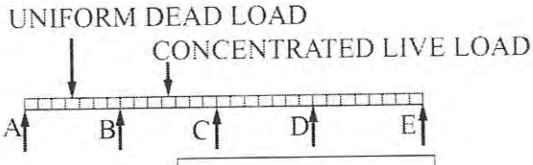
- ○ A. unstable
- ○ B. stable and determinate
- ○ C. indeterminate one degree
- ○ D. indeterminate two degrees

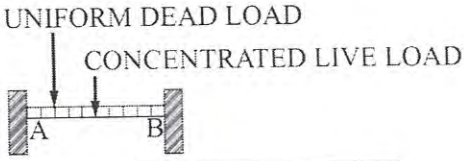
NEXT→

59. Match each of the beams diagrammed below with its correct description.







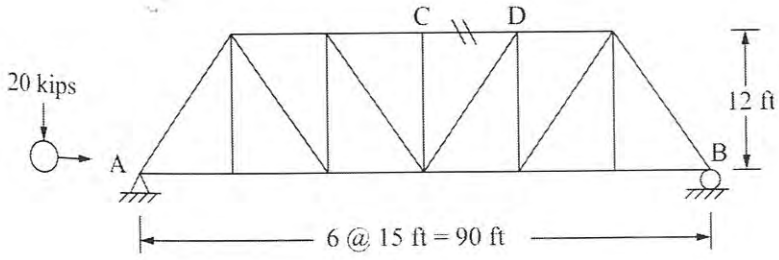


Beam Types

- Fixed-end
- Indeterminate
- Multispan
- Simple-span

NEXT→

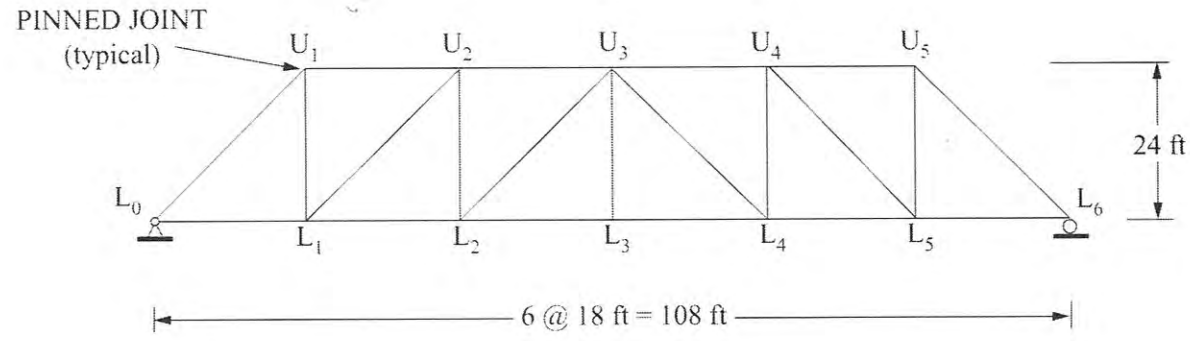
60. A concentrated load of 20 kips moves through the truss shown. Neglecting the weight of the truss, the maximum force (kips) in Member CD due to the moving load is most nearly:

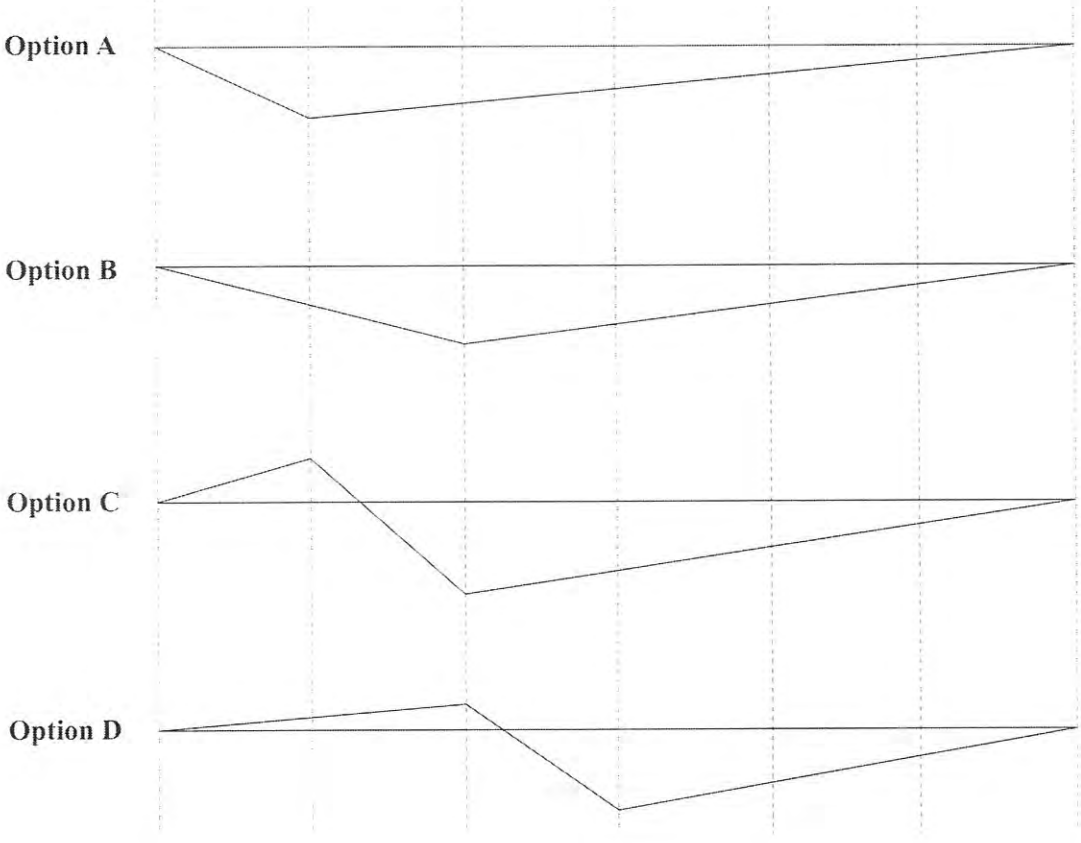


- O A. 12.5
- O B. 25
- O C. 37.5
- O D. 50

NEXT→

61. Which of the vertical-load influence lines shown below is correct for Member U_2U_3 of the truss shown below?

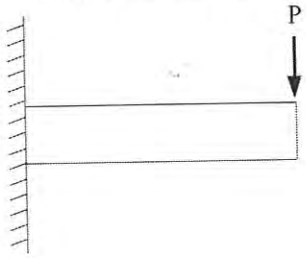




- ○ A. Option A
- ○ B. Option B
- ○ C. Option C
- ○ D. Option D

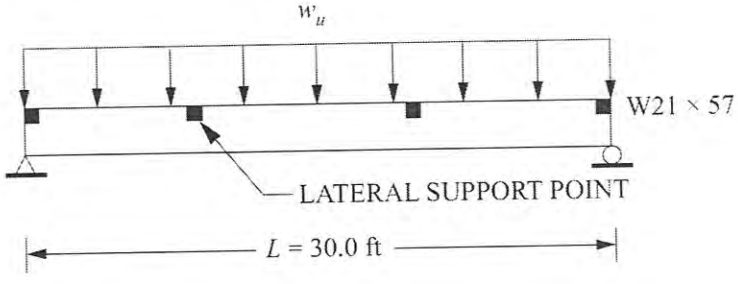
NEXT→

62. The beam shown below is known as a:



- ○ A. cantilever beam
- ○ B. statically indeterminate beam
- ○ C. simply supported beam
- ○ D. continuously loaded beam

63. The W21 × 57 steel beam shown in the figure below has its compression flange laterally braced at the one-third points over its full length. Assume $F_y = 50$ ksi and $C_b = 1.0$ for the critical segment. The maximum factored load w_u (kips/ft) that the beam can carry for this length is most nearly:

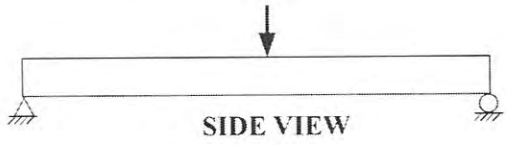


- ○ A. 2.658
- ○ B. 3.360
- ○ C. 4.302
- ○ D. 4.778

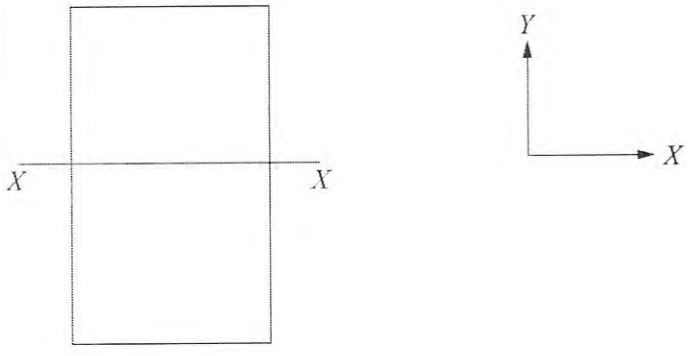
NEXT→

44 The figure shown below is the cross section of a steel rectangular beam. The beam is subjected to transverse loading applied in the Y-direction.

Mark the location on the cross section that experiences maximum normal stress.



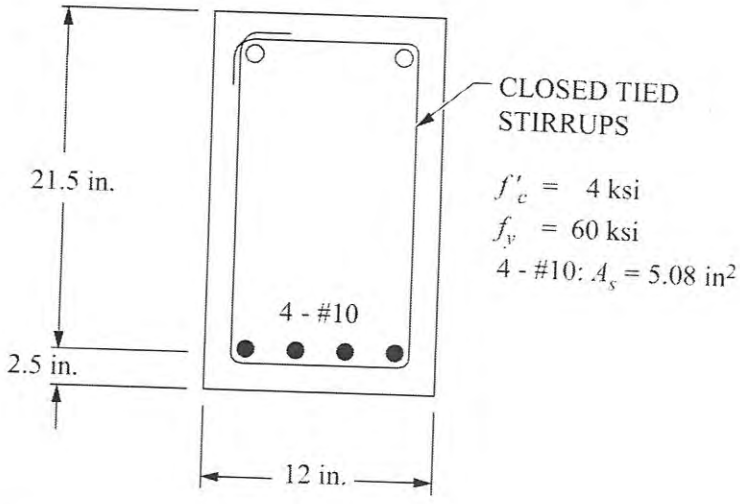
SIDE VIEW



CROSS SECTION

NEXT→

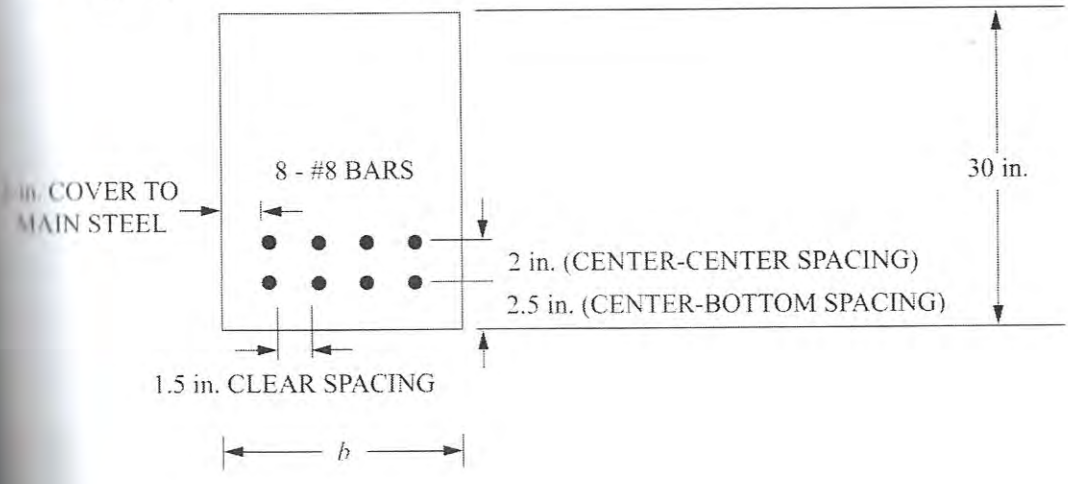
65. According to ACI 318-11, the value of ϕ that should be used in computing the design moment strength ϕM_n for the beam section shown below is most nearly:



- O A. 0.80
- O B. 0.81
- O C. 0.84
- O D. 0.90

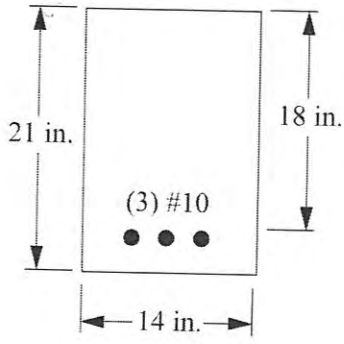
NEXT→

A reinforced concrete beam is subjected to a factored moment $M_u = 648$ ft-kips. For concrete $f'_c = 4{,}000$ psi, and for steel $f_y = 60{,}000$ psi. The beam is reinforced with eight #8 bars in two rows, positioned as shown in the figure below. It may be assumed without verification that $\phi = 0.90$. The minimum adequate overall width b (to the nearest whole inch) for this beam is most nearly:



A. 10
B. 12
C. 13
D. 15

67. The flexural design strength (ft-kips) of the reinforced concrete beam section shown is mos nearly:

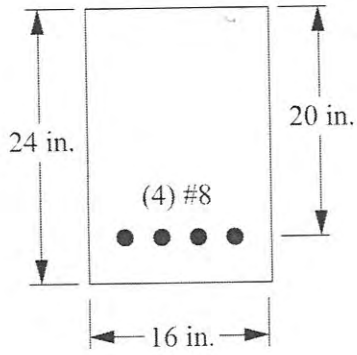


$f'_c = 4{,}000$ psi
$f_y = 60$ ksi

- ○ A. 267
- ○ B. 297
- ○ C. 319
- ○ D. 354

NEXT→

68. The flexural design strength (ft-kips) of the reinforced concrete beam section shown is most nearly:



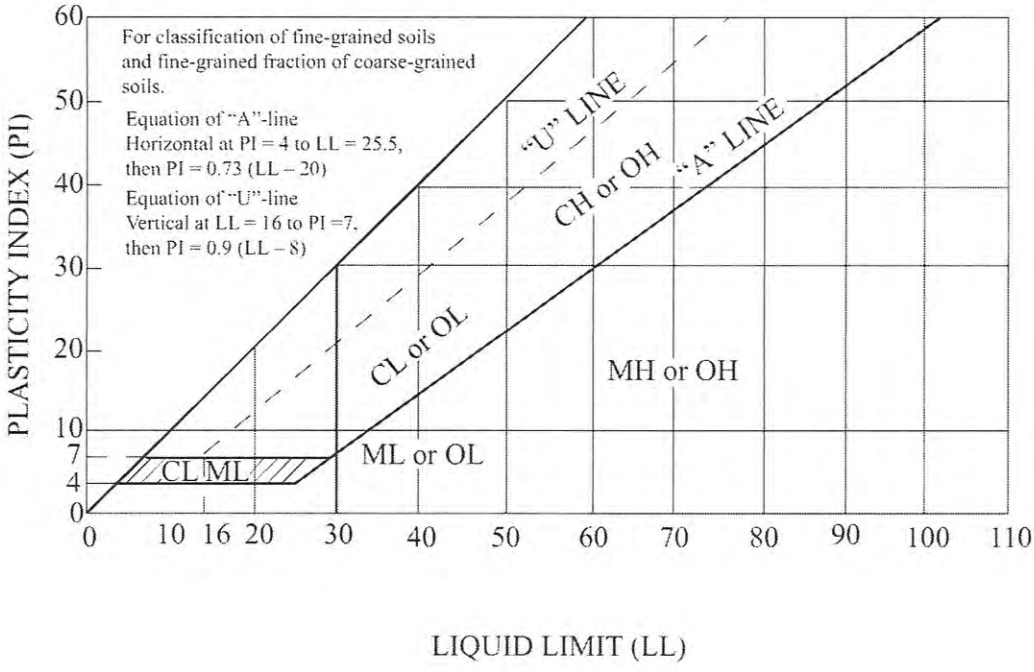
$f'_c = 4{,}000$ psi

$f_y = 60$ ksi

- A. 258
- B. 289
- C. 314
- D. 349

NEXT→

69. Mark the area of the Atterberg chart provided that is associated with an elastic, nonorganic silt.



70. An undisturbed sample of soil has a specific gravity of solids of 2.70, a moisture content of 10.5%, and a void ratio of 0.63. The degree of saturation is most nearly:

- ○ A. 25%
- ○ B. 45%
- ○ C. 65%
- ○ D. 85%

Direct shear test data of a sand are shown below:

Area of sample = 16 in^2
Normal load at failure = 512 lb
Shear stress at failure = 16 psi

The angle of friction is most nearly:

- A. 0°
- B. 27°
- C. 30°
- D. 63°

Subsurface exploration indicates that a level site has a 10-ft upper layer of sand. The groundwater table is at the ground surface. The unit weight of the sand is 135.0 pcf. The effective overburden stress (psf) at a depth of 10 ft is most nearly:

- A. 625
- B. 725
- C. 1,350
- D. 1,975

NEXT→

73. A 12-ft-high retaining wall has backfill of granular soil with an internal angle of friction of 30° and a unit weight of 125 pcf. The Rankine passive earth pressure (lb/ft^2) possible on the wall is most nearly:

- ○ A. 2,250
- ○ B. 3,000
- ○ C. 9,000
- ○ D. 27,000

74. A strip footing having a width $B = 2$ ft is to be constructed at ground surface ($D_f = 0$). Underlying the footing is sand having the following bearing capacity factors: $N_c = 0$, $N_\gamma = 25$, and $N_q = 20$. The unit weight of sand (γ) = 120 pcf. Recalling that $q_{ult} = cN_c + \gamma D_f N_q + 0.5\,\gamma B N_\gamma$, the ultimate bearing capacity q_{ult} (psf) of the footing is most nearly:

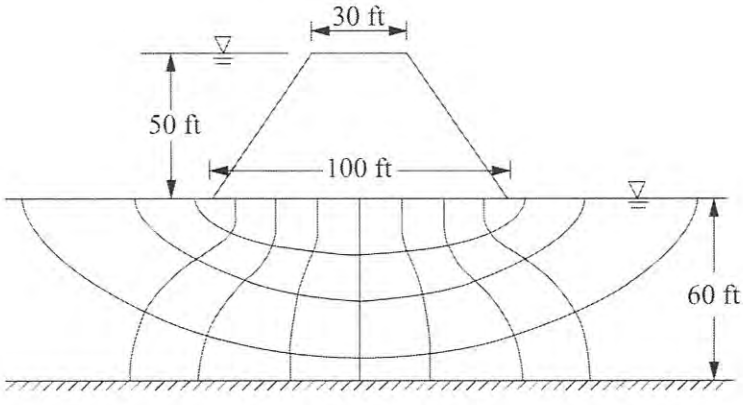
- ○ A. 1,200
- ○ B. 2,400
- ○ C. 3,000
- ○ D. 4,800

NEXT→

A normally consolidated 10-ft clay layer is surcharged, which causes a decrease in thickness. The coefficient of consolidation is 0.16 ft^2 per day and the time factor is 1.2 for $U = 50\%$. The clay layer is confined between two layers of dense sand. The time (days) required for 50% consolidation is most nearly:

- A. 5
- B. 38
- C. 188
- D. 750

The figure below shows the flow net for the cross section of a dam that is 600 ft long (measured perpendicular to the cross section). Assuming a uniform cross section, the total seepage (ft^3/day) under the dam would be most nearly:



$k_h = k_v = 4 \times 10^{-4}$ in./sec

- A. 63
- B. 37,800
- C. 51,840
- D. 453,600

NEXT→

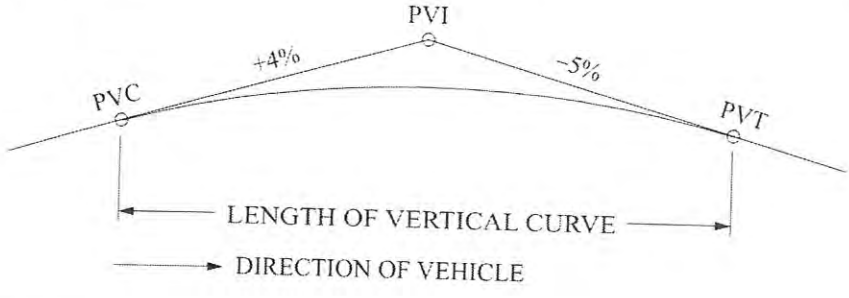
77. An equal tangent vertical curve has the following data:

Station of PVI = 30+00
Elevation of PVI = 200.00 ft
Back tangent grade = –6%
Forward tangent grade = +4%
Length of curve = 800 ft

The curve elevation (ft) at Station 31+00 is most nearly:

- O A. 190.38
- O B. 209.63
- O C. 211.63
- O D. 244.63

78. A highway profile is shown in the figure. If the design stopping sight distance is 600 ft, the driver's eye height above the roadway surface is 3.50 ft, and the height of an object in the roadway to be avoided by stopping is 1.00 ft, the minimum design length (ft) of the vertical curve is most nearly:



- O A. 3,600
- O B. 1,966
- O C. 1,136
- O D. 1,017

NEXT→

79. A horizontal circular curve has the following data:

$I = 40°50'$
$R = 600.00$
Station of $PI = 20+00.00$

The station of the PT is most nearly:

- A. 22+00.76
- B. 22+04.27
- C. 22+23.34
- D. 22+32.3

80. At two-way stop-controlled intersections, the sight distance required for minor street movements is determined by:

- A. approach sight triangles
- B. departure sight triangles
- C. stopping sight distance
- D. decision sight distance

NEXT→

81. A flexible pavement system is to be designed using the AASHTO structural number design method with the following criteria:

Material	Minimum Thickness (in.)	Coefficient of Structural Layer
AC surfacing	2	0.44
Aggregate base	4	0.25
Aggregate subbase	4	0.10
Structural number = 2.50		

If the minimum thicknesses of the surfacing and aggregate base are used, the required thickness (in.) of the aggregate subbase is most nearly:

- O A. 4
- O B. 5
- O C. 6.5
- O D. 8.5

82. For a given loading, soil conditions, and design life, which of the following pavement types will most likely be the thinnest highway pavement design?

- O A. Hot-mix asphalt
- O B. Warm-mix asphalt
- O C. Portland cement concrete
- O D. Composite hot-mix asphalt over Portland cement concrete

NEXT→

An urban intersection is being reconstructed to address safety problems, and it is estimated that the two mutually exclusive countermeasures have a crash reduction factor of 0.25 and 0.15, respectively. If the expected number of crashes per year is 10 and no significant growth in traffic is anticipated, the expected number of average crashes per year after reconstruction is most nearly:

- A. 3.6
- B. 4
- C. 6
- D. 6.4

A person is driving a car on a road that has a gravel surface. A deer suddenly leaps into the road. The road is on a 10% downgrade, and the car is traveling at 50 mph when the deer appears. The driver's reaction time is 1.5 sec, and the coefficient of friction on the gravel surface is 0.65. The coefficient of friction $f = \dfrac{\text{deceleration rate, } a}{32.2 \text{ ft/sec}^2}$

The total distance (ft) required to stop is most nearly:

- A. 153
- B. 222
- C. 242
- D. 262

NEXT→

85. A freeway lane has a volume of 1,400 vehicles/hr and an average vehicle speed of 45 mph. The time spacing (sec) between vehicles (center to center) is most nearly:

- O A. 2.6
- O B. 5.2
- O C. 15
- O D. 31

86. At a pedestrian crosswalk, the initial WALK signal is displayed for 6.0 sec, after which a flashing DON'T WALK signal is displayed. The pedestrian walking speed is 4 ft/sec, and the street to be crossed is 50 ft wide. After the green, the yellow interval is 3.5 sec. The all-red interval is 0.5 sec, during which time no pedestrians are in the street. The length of time (sec) the green must be displayed is most nearly:

- O A. 9.5
- O B. 15.0
- O C. 22.0
- O D. 22.5

NEXT→

87. Consider the following equation:

$$K = \frac{[C]^2[D]^2}{[A]^4[B]}$$

The equation above is the formulation of the chemical equilibrium constant equation for which of the following reactions?

- A. $C_2 + D_2 \leftrightarrow A_4 + B$
- B. $A_4 + B \leftrightarrow C_2 + D_2$
- C. $4C + 2D \leftrightarrow 2A + B$
- D. $4A + B \leftrightarrow 2C + 2D$

88. A lime soda softening plant produces a municipal supply of 5 MGD. The plant includes two clarifiers, each with a diameter of 65 ft and sidewater depth of 12 ft. The clarifier residence time (hours) for parallel operation is most nearly:

- A. 0.35
- B. 1.43
- C. 2.86
- D. 3.19

NEXT→

89. Consider the equation:

$$As_2O_3 + 3\ C \rightarrow 3\ CO + 2\ As$$

Atomic weights may be taken as 75 for arsenic, 16 for oxygen, and 12 for carbon. According to the equation above, the reaction of 1 standard gram mole of As_2O_3 with carbon will result in the formation of:

- O A. 1 gram mole of As
- O B. 28 grams of CO
- O C. 150 grams of As
- O D. a greater amount by weight of CO than of As

90. A surface water treatment plant has multiple filters. Each filter has a surface area of 100 ft^2. The filter backwash rate is 15 gpm/ft^2, and the backwash duration is 12 min. The quantity (gal) of water required for backwash of each filter is most nearly:

- O A. 4,800
- O B. 13,200
- O C. 18,000
- O D. 576,000

NEXT→

90. A municipal wastewater treatment plant is processing a waste flow with a 5-da
200 mg/L at 20°C. If the BOD rate constant k_1 (base e) at 20°C is 0.23 day^{-1}, the ul
BOD (mg/L) of the raw wastewater at 20°C is most nearly:

- A. 133
- B. 233
- C. 292
- D. 420

91. You are designing an aerobic system to biodegrade benzene (C_6H_6). The biodegradation follows the chemical reaction below (note that you must balance this equation). The benzene concentration is 500 mg/L. (C = 12, H = 1, O = 16)

$$C_6H_6 + O_2 \rightarrow CO_2 + H_2O$$

The amount of oxygen (mg/L) that must be consumed to completely biodegrade the benzene is most nearly:

- A. 200
- B. 500
- C. 800
- D. 1,600

NEXT→

93. Operational manuals, warranties, guarantees, and as-built drawings are generally provided to the owner during which phase of the project?

- O A. Construction
- O B. Procurement
- O C. Close-out
- O D. Feasibility

94. A loader has a full-bucket capacity of 3 yd^3, and the average time required to place one bucketload of soil into a truck is 1 min. The loader is supported by four trucks with a volume of 15 yd^3 each and a cycle time of 12 min plus the time to load the truck.

The ideal productivity (yd^3/hr) of this system is most nearly:

- O A. 180
- O B. 212
- O C. 277
- O D. 300

NEXT→

The average production of the excavator is the controlling factor in a highway ditch-cleaning contract. Excavators with four different bucket sizes are available as rental units. The hourly rental rate is directly proportional to the bucket capacity of the excavator. Assume that production (loose yd^3/hr) is equal to (excavator cycles per hour) × (average bucket payload in LCY per cycle). The excavator characteristics are as follows:

Excavator	Minimum Cycle Time (min)	Average Bucket Payload (LCY)
1	0.25	0.50
2	0.33	1.00
3	0.50	1.75
4	0.58	2.00

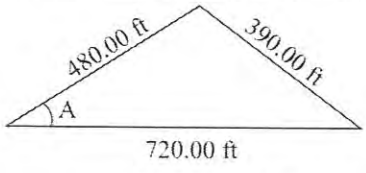
The optimally efficient excavator is:

- A. Excavator 1
- B. Excavator 2
- C. Excavator 3
- D. Excavator 4

96. An embankment having a volume of 320,000 yd^3 is to be constructed from local borrow. The dry unit weight and moisture content of the borrow material were determined to be 106 pcf and 18.2%, respectively. The embankment material has a total unit weight of 122 pcf and a moisture content of 16.7%. The volume of borrow (yd^3) needed to construct the embankment is most nearly:

- O A. 274,100
- O B. 315,500
- O C. 324,500
- O D. 373,600

97. The value of Angle A in the following figure is most nearly:



NOT TO SCALE

- O A. 30° 18' 47"
- O B. 32° 47' 50"
- O C. 39° 05' 38"
- O D. 42° 35' 09"

NEXT→

The cross-sectional areas to be excavated (cut) at certain sections of a road project are as follows:

Station	Area (ft^2)
3+00	247
4+00	269
4+35	322
5+00	395
5+65	418
6+00	293
7+00	168

Using the prismoidal method, the earth to be excavated (yd^3) between Sections 4+35 and 5+65 is most nearly:

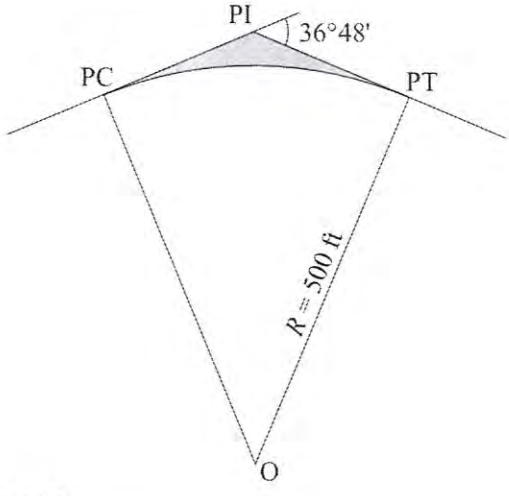
- A. 1,460
- B. 1,840
- C. 1,860
- D. 1,900

NEXT→

99. A closed traverse is run from Point B to Point K. The bearing and distance from Point B to Point C are N 18°22′ E and 487.52 ft; from Point C to Point D are S 87°10′ E and 789.16 ft; and from Point D to Point K are S 78°37′ E and 825.97 ft. The coordinates of Point B are 11,250.61 N and 8,755.32 E. The coordinates of Point K are 11,511.15 N and 10,507.23 E. The error of closure (ft) in latitude is most nearly:

- ○ A. 0.12
- ○ B. 0.27
- ○ C. 0.38
- ○ D. 0.49

100. The area inside the quadrilateral, PC, PI, PT, and O, equals 83,164 ft^2. The shaded area (ft^2) between the circular curve and the tangents is most nearly:



- ○ A. 2,879
- ○ B. 3,577
- ○ C. 5,407
- ○ D. 8,286

SOLUTIONS

FE CIVIL SOLUTIONS

Detailed solutions for each question begin on the next page.

1	C
2	D
3	C
4	A
5	A
6	C
7	A
8	B
9	D
10	B
11	C
12	24
13	A
14	D
15	C
16	A, E
17	C
18	A
19	B
20	B
21	C
22	B
23	A
24	D
25	C

26	A
27	B
28	D
29	C
30	B
31	D
32	B
33	D
34	B
35	C
36	A
37	A
38	C
39	B
40	D
41	C
42	B
43	D
44	D
45	D
46	A
47	D
48	C
49	A
50	B

51	A
52	B
53	B
54	B
55	C
56	A
57	A
58	B
59	see solution
60	C
61	B
62	A
63	B
64	see solution
65	C
66	D
67	A
68	A
69	see solution
70	B
71	B
72	B
73	D
74	C
75	C

76	B
77	B
78	B
79	B
80	B
81	C
82	C
83	D
84	D
85	A
86	B
87	D
88	C
89	C
90	C
91	C
92	D
93	C
94	A
95	C
96	B
97	A
98	C
99	A
100	A

FE CIVIL SOLUTIONS

1. Refer to the Mathematics section of the *FE Reference Handbook.*

$$A = \int_2^5 3x^2 dx = x^3 \Big|_2^5 = 5^3 - 2^3$$

$$= 117$$

THE CORRECT ANSWER IS: C

2. $$\int x^3 - x + 1 = \frac{x^4}{4} - \frac{x^2}{2} + x + C$$

THE CORRECT ANSWER IS: D

3. The roots of a function are defined as points where $F = 0$.

In this case, divide the polynomials:

$$x+1 \overline{)\, x^3 + 6x^2 + 11x + 6}$$

$$x^2 + 5x + 6$$

$$\underline{x^3 + x^2}$$

$$5x^2 + 11x$$

$$\underline{5x^2 + 5x}$$

$$6x + 6$$

$$\underline{6x + 6}$$

$$0$$

$x^2 + 5x + 6$ factors to $(x + 2)(x + 3)$. Therefore, the roots of F are $x = -2$ and $x = -3$

THE CORRECT ANSWER IS: C

4. Refer to the Mathematics section of the *FE Reference Handbook.*

$(x-h)^2+(y-k)^2+(z-m)^2=r^2$ with center at (h, k, m)

$(x-0)^2+(y-1)^2+(z-(-2))^2=r^2$

$x^2+(y-1)^2+(z+2)^2=81$

THE CORRECT ANSWER IS: A

5. $$\frac{(1-i)^2}{(1+i)^2}=\frac{1-2i+i^2}{1+2i+i^2}=\frac{1-1-2i}{1-1+2i}=\frac{-i}{i}=-1$$

THE CORRECT ANSWER IS: A

6. The cross product of vectors **A** and **B** is a vector perpendicular to **A** and **B**.

$$\begin{vmatrix}\mathbf{i} & \mathbf{j} & \mathbf{k}\\ 2 & 4 & 0\\ 1 & 1 & -1\end{vmatrix}=\mathbf{i}(-4)-\mathbf{j}(-2-0)+\mathbf{k}(2-4)=-4\mathbf{i}+2\mathbf{j}-2\mathbf{k}$$

To obtain a unit vector, divide by the magnitude.

$$\text{Magnitude}=\sqrt{(-4)^2+2^2+(-2)^2}=\sqrt{24}=2\sqrt{6}$$

$$\frac{-4\mathbf{i}+2\mathbf{j}-2\mathbf{k}}{2\sqrt{6}}=\frac{-2\mathbf{i}+\mathbf{j}-\mathbf{k}}{\sqrt{6}}$$

THE CORRECT ANSWER IS: C

Refer to the Engineering Probability and Statistics section of the *FE Reference Handbook.*

$$\text{Mean} = \frac{1}{N}\sum_{i=1}^{N} x_i = \frac{801}{9} = 89$$

95
91
90 ⎫
90 ⎬ Mode
Median 90 ⎭
88
87
85
85

The mean of the sample is 89. The median of the sample is 90. The mode of the sample is 90. Therefore, the median and the mode are equal.

THE CORRECT ANSWER IS: A

Refer to the Engineering Probability and Statistics section of the *FE Reference Handbook.*

Binomial distribution
p = 0.5 (chance of getting a head)
q = 0.5 (chance of not getting a head)
n = 10 (number of trials)
x = 4 (number of heads)

$$P_{10}(4) = \frac{10!}{4!6!}(0.5^4)(0.5^6) = \frac{(10)(9)(8)(7)}{(4)(3)(2)(1)}(0.5)^{10}$$

$$= 0.2051$$

THE CORRECT ANSWER IS: B

9. Refer to the Engineering Probability and Statistics section of the *FE Reference Handbook*.

There is only one throw, 6 and 6, that sums to 12. There are 36 possible rolls of the dice so therefore 35/36 will have a sum less than 12.

35/36 = 0.972

THE CORRECT ANSWER IS: D

10. $f(x) = x^3 + x^2 - 3$

$f'(x) = 3x^2 + 2x$

$x(3x + 2) = 0$

$x = 0$

$3x = -2$

$x = -2/3$

$f''(x) = 6x + 2$

$6x + 2 = 0$

$x = -1/3$

$f''(x)$ negative below $x = -1/3$
$f''(x)$ positive above $x = -1/3$

Since $f''(x) = 0$ and $f''(x)$ changes sign at $x = -1/3$, the inflection point is at $x = -1/3$.

THE CORRECT ANSWER IS: B

11. The following formulas are in the first five rows of Column B

1. $A1^3 + A$1^2 - 3
2. $A2^3 + A$1^2 - 3
3. $A3^3 + A$1^2 - 3
4. $A4^3 + A$1^2 - 3
5. $A5^3 + A$1^2 - 3

In spreadsheet equation format, the formula in Cell B5 is

$A5^3 + A$1^2 - 3

THE CORRECT ANSWER IS: C

Row	Column A	Value of A
4	6	6
5	A4 + A4	12
6	A5 + A4	18
7	A6 + A4	24

THE CORRECT ANSWER IS: 24

K = 2 gives A = 17/2 = 8.5
K = 3 gives A = 8.5/3 = 2.83
K = 4 gives A = 2.83/4 = 0.71

THE CORRECT ANSWER IS: A

Step	VAR
1	0
2	2
3	4
4	6
EXIT LOOP	

At the conclusion of the routine, VAR = 6.

THE CORRECT ANSWER IS: D

Refer to the Ethics section of the *FE Reference Handbook*. Section B.1 in the Rules of Professional Conduct states:

Licensees shall undertake assignments only when qualified by education or experience in the specific technical fields of engineering or surveying involved.

THE CORRECT ANSWER IS: C

16. Refer to the NCEES Rules of Professional Conduct, Section B, in the Ethics section of the *FE Reference Handbook.*

THE CORRECT ANSWERS ARE: A AND E

17. Refer to the NCEES Rules of Professional Conduct in the Ethics section of the *FE Reference Handbook.* Licensees may express a professional opinion publicly only when it is founded on adequate knowledge of the facts and a competent evaluation of the subject matter.

THE CORRECT ANSWER IS: C

18. *Black's Law Dictionary* defines *lien* as a claim on property for payment of debt.

THE CORRECT ANSWER IS: A

19. Refer to the Engineering Economics section of the *FE Reference Handbook.*

$A = P\ (A/P, i\%, n)$

$= 100{,}000\ (A/P, 1\%, 60)$

$= 100{,}000\ (0.0222)$

$= \$2{,}220/\text{month}$

THE CORRECT ANSWER IS: B

10. The easiest way to solve this problem is to look at the present worth of each option.

The present worth values are all given by:

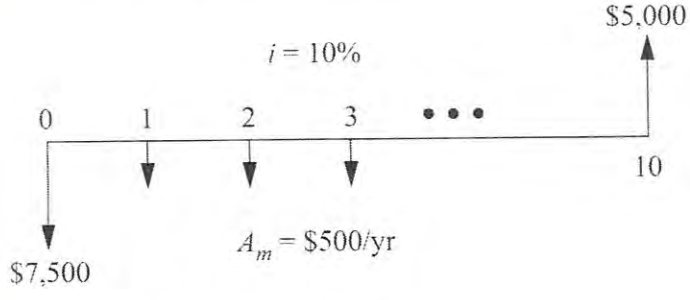
P = First Cost + Annual Cost × (P/A, 12%, 8) – Salvage Value × (P/F, 12%, 8)
= First Cost + Annual Cost × 4.9676 – Salvage Value × 0.4039

Then P(A) = \$63,731
P(B) = \$63,392
P(C) = \$63,901
P(D) = \$63,222

The cash flows are all costs, so the two most preferable projects, those with the lowest present worth costs, are B and D, and the difference between them is \$170.

THE CORRECT ANSWER IS: B

11. Refer to the Engineering Economics section of the *FE Reference Handbook*.



$$A = A_m + P\left(\frac{A}{P}, i, n\right) - SV\left(\frac{A}{F}, i, n\right)$$

$$= 500 + 7,500\left(\frac{A}{P}, 10\%, 10\right) - 5,000\left(\frac{A}{F}, 10\%, 10\right)$$

$$= 500 + 7,500(0.16275) - 5,000(0.06275)$$

$$= \$1,407 \text{ per year}$$

THE CORRECT ANSWER IS: C

22. \$1.50 (5,000) = \$7,500
\$0.50 (5,000) = \$2,500
Annual savings = \$7,500 – \$2,500 = \$5,000
Additional investment = \$15,000 – \$1,000 = \$14,000
Payback = \$14,000/\$5,000 = 2.8 years

THE CORRECT ANSWER IS: B

23. Refer to Resolution of a Force in the Statics section of the *FE Reference Handbook.*

$$R_x = \sum F_{xi}, \qquad R_y = \sum F_{yi}, \qquad i = 1,2,3$$

$$R_x = 2.12 + 5\cos 105° = 2.12 - 1.29 = 0.83 \text{ N}$$

$$R_y = 2.12 + 5\sin 105° = 2.12 + 4.83 = 6.95 \text{ N}$$

$$R = \sqrt{R_x{}^2 + R_y{}^2} = \sqrt{0.83^2 + 6.95^2} = 6.999 \text{ N}$$

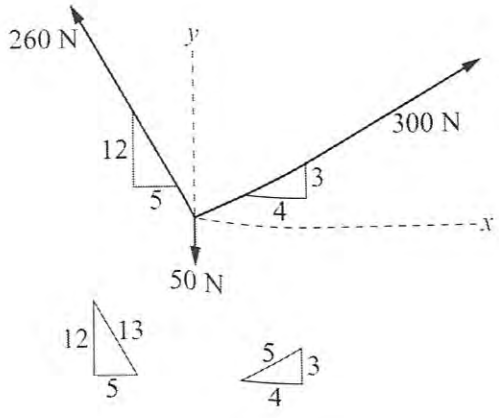
THE CORRECT ANSWER IS: A

24. $$R_y = \Sigma F_y = \frac{12}{13}(260) + \frac{3}{5}(300) - 50 = 370$$

$$R_x = \Sigma F_x = -\frac{5}{13}(260) + \frac{4}{5}(300) = 140$$

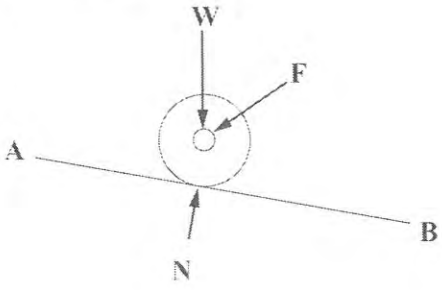
$$R = \sqrt{R_x^2 + R_y^2} = \sqrt{370^2 + 140^2}$$

$$R = 396 \text{ N}$$



THE CORRECT ANSWER IS: D

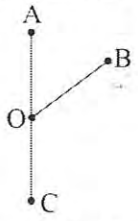
18. Refer to the Systems of Forces in the Statics section of the *FE Reference Handbook*. Draw a free-body diagram.



Since force Σ vectors = 0

THE CORRECT ANSWER IS: C

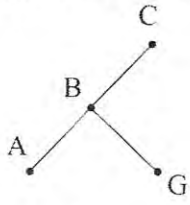
26. Zero-force members usually occur at joints where members are aligned as follows:



That is, joints where two members are along the same line (OA and OC) and the third member is at some arbitrary angle create a zero-force member. That member (OB) is a zero-force member because the forces in OA and OC must be equal and opposite.

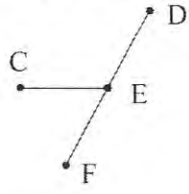
For this specific problem, we immediately examine Joints B and E:

B:



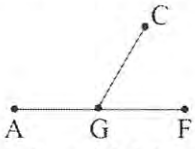
BG is a zero-force member

E:



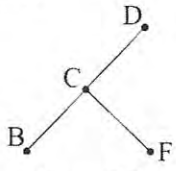
CE is a zero-force member

Now, examine Joint G. Since BG is zero-force member, the joint effectively looks like:



and, therefore, **CG** is another zero-force member.

Finally, examine Joint C. Since both CG and CE are zero-force members, the joint effectively looks like:



and, therefore, CF is another zero-force member. Thus, BG, CE, CG, and CF are the zero-force members.

THE CORRECT ANSWER IS: A

The location of the centroid from the y-axis in the direction parallel to the x-axis is given by:

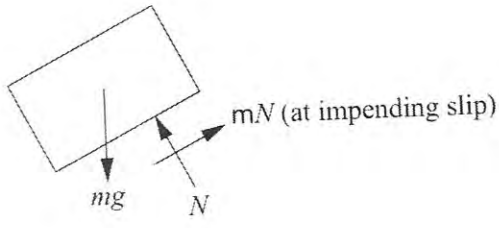
$$\bar{x} = \frac{1}{A}\int_A x\,dA \qquad \text{where } dA = (y_2 - y_1)\,dx$$

$$\bar{x} = \frac{\int_0^3 x\left(x - \frac{x^2}{3}\right)dx}{\int_0^3 \left(x - \frac{x^2}{3}\right)dx} \quad \text{or} \quad \bar{x} = \frac{\int_0^3 \left(x^2 - \frac{1}{3}x^3\right)dx}{\int_0^3 \left(x - \frac{1}{3}x^2\right)dx}$$

THE CORRECT ANSWER IS: B

Normal to the plane:

$\Sigma F_n = 0$: $N - mg\cos\phi = 0 \rightarrow N = mg\cos\phi$



Tangent to the plane:

$\Sigma F_t = 0$: $-mg\sin\phi + \mu N = 0$

$\therefore -mg\sin\phi + \mu mg\cos\phi = 0$

$$\frac{\sin\phi}{\cos\phi} = \tan\phi = \mu$$

$\tan\phi = 0.25$

THE CORRECT ANSWER IS: D

29. $v^2 = v_o^2 + 2a_c(S - S_o)$

$v_o^2 = v^2 - 2a_c(S - S_o)$

$= (60 \text{ ft/sec})^2 - 2\ (12 \text{ ft/sec}^2)(140 \text{ ft})$

$= 3{,}600 \text{ ft}^2/\text{sec}^2 - 3{,}360 \text{ ft}^2/\text{sec}^2$

$= 240 \text{ ft}^2/\text{sec}^2 \quad v_o = 15.5 \text{ ft/sec}$

THE CORRECT ANSWER IS: C

30. Let subscript 1 refer to the ball and subscript 2 refer to the block.

$m_1 v_1 + m_2 v_2 = m_1 v'_1 + m_2 v'_2$

$m_2 = 2\, m_1$

$m_1(10 \text{ ft/sec}) + 0 = m_1 v'_1 + 2\, m_1(4 \text{ ft/sec})$

$\Rightarrow v'_1 = 2 \text{ ft/sec}$

$$e = \frac{(v'_2 - v'_1)}{(v_1 - v_2)} = \frac{(4-2)}{(10-0)} = \frac{2}{10} = 0.20$$

THE CORRECT ANSWER IS: B

31. Refer to Impact in the Dynamics section of the *FE Reference Handbook.*

Energy may or may not be conserved. It is conserved only if the coefficient of restitution is 1.00. Momentum is always conserved.

THE CORRECT ANSWER IS: D

11. Refer to Principle of Work and Energy in the Dynamics section of the *FE Reference Handbook.*

$T_2 + U_2 = T_1 + U_1 + W_{1\to 2}$

$W_{1\to 2} = 0$

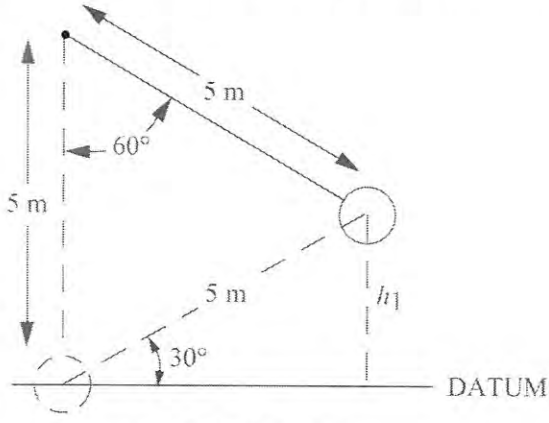
$T_1 = 0$

$T_2 = \frac{1}{2}mv_2^2$

$U_1 = mgh_1$

$U_2 = 0$

$\frac{1}{2}mv_2^2 = mg(2.5) \Rightarrow v_2 = \sqrt{5g} = \sqrt{5(9.81)} = 7$ m/s



$h_1 = 5 \sin 30° = 2.5$

THE CORRECT ANSWER IS: B

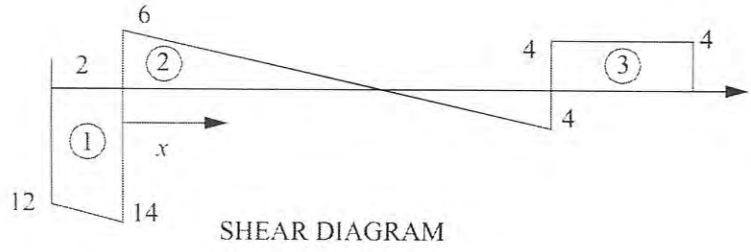
12. $\frac{10 \text{ m}}{10 \text{ kN}} = \frac{x}{6 \text{ kN}}$

$x = 6$ m

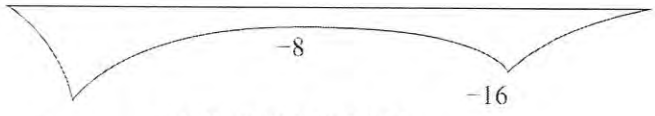
Area 1 $= 13(2) = 26$ kN·m

Area 2 $= \frac{6(6)}{2} = 18$ kN·m

Area 3 $= 4(4) = 16$ kN·m



SHEAR DIAGRAM



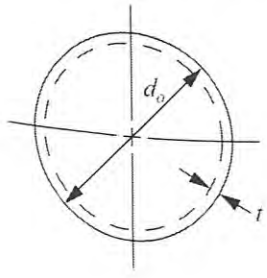
MOMENT DIAGRAM

Maximum magnitude of the bending moment is 26 kN·m.

THE CORRECT ANSWER IS: D

34. Refer to Cylindrical Pressure Vessel in the Mechanics of Materials section of the *FE Reference Handbook.*

The cylinder can be considered thin-walled if $t \le d_o/2$. In this case, $t = 12$ mm and $r_o = d_o/2 = 362$ mm. Thus



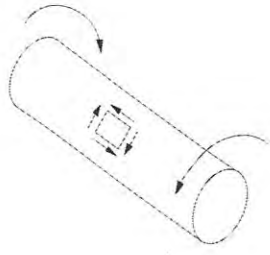
$$\sigma_t = \frac{P_i r}{t}$$

$$\text{where } r = \frac{r_i + r_o}{2} = \frac{350 + 362}{2} = 356 \text{ mm}$$

$$\sigma_t = \frac{(1.680 \text{ MPa})(356 \text{ mm})}{12 \text{ mm}} = 49.8 \text{ MPa}$$

THE CORRECT ANSWER IS: B

35. $$\tau = \frac{Tr}{J} = \frac{T\frac{d}{2}}{\frac{\pi d^4}{32}} = \frac{16T}{\pi d^3}$$

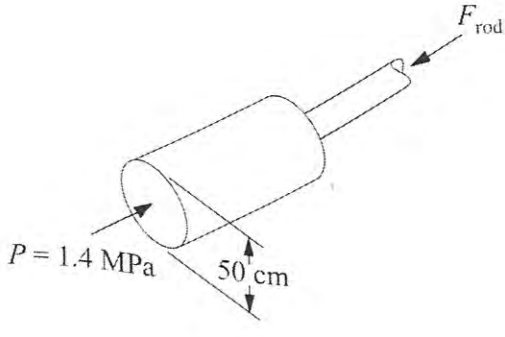


$$T = \frac{\pi d^3 \tau}{16} = \frac{\pi(0.2)^3(840 \times 10^3)}{16}$$

$$T = 1{,}319 \text{ N·m}$$

THE CORRECT ANSWER IS: C

36. $$\Sigma F = PA = \left(1.4 \times 10^6\right)\left(\frac{\pi(0.5)^2}{4}\right) = F_{\text{rod}}$$



$$F_{\text{rod}} = 275 \text{ kN} = \sigma A = 68 \times 10^6 A$$

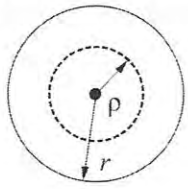
$$A = 40.4 \times 10^{-4} \text{ m}^2$$

THE CORRECT ANSWER IS: A

17. Refer to Torsion in the Mechanics of Materials section of the *FE Reference Handbook.*

$$\tau = \frac{T\rho}{J}$$

$\therefore$ max τ when $\rho = r$



THE CORRECT ANSWER IS: A

18. $P = 1{,}300$ lb $\quad A = (0.5)^2 \frac{\pi}{4} = 0.196$ in^2 $\quad L = 12$ in.

$\delta = 0.009$ in.

$\delta = \frac{PL}{AE}$ rearranged gives

$$E = \frac{PL}{\delta A} = \frac{(1{,}300)(12)}{(0.009)(0.196)} = 8.84 \times 10^6 \text{ psi} = 8{,}840 \text{ ksi}$$

THE CORRECT ANSWER IS: C

19. Refer to Mohr's Circle in the Mechanics of Material section of the *FE Reference Handbook.*

From a constructed Mohr's Circle, the maximum inplane shear stress is $\tau_{max} = R$.

$$R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^{\ 2}}$$

$$R = \sqrt{\left(\frac{40 - 20}{2}\right)^2 + 10^2}$$

$$R = \sqrt{200}$$

$R = 14.1$ ksi

THE CORRECT ANSWER IS: B

40. The Euler formula is used for elastic stability of relatively long columns, subjected to concentric axial loads in compression.

THE CORRECT ANSWER IS: D

41. It is assumed that the concrete w/c ratio at the plant (and hence at the jobsite) was as required for proper strength.

THE CORRECT ANSWER IS: C

42. The moisture content of each aggregate includes: (1) water that would be needed to bring aggregates to SSD condition (the absorbed water) and (2) the excess water that is free to add to the mix water. Since the as-used moisture content is greater than the absorption for each aggregate, each aggregate contributes the excess water to the mix, thus reducing the water that must be added to mix. The water added to the mix is the water computed for oven-dry aggregates (305 lb/yd^3) plus the excess water in each aggregate.

Final water = $305 - [(2.0\% - 0.5\%)/100] \times 1{,}674 - [(6.0\% - 0.7\%)/100] \times 1{,}100 = 221.6\ lb/yd^3$

THE CORRECT ANSWER IS: B

43. Refer to the definition of *Charpy Impact Test* in the Materials Science/Structure of Matter section of the *FE Reference Handbook*.

THE CORRECT ANSWER IS: D

44. By definition, a metal with high hardness has a high tensile strength and a high yield strength.

THE CORRECT ANSWER IS: D

15. $\frac{\rho v^2}{2} = gh(\rho - \rho_{air})$

$$\therefore h = \frac{\rho v^2}{2g(\rho - \rho_{air})} \approx \frac{v^2}{2g} \approx \frac{(2)^2}{(2)(9.8)} \approx 0.204 \text{ m}$$

THE CORRECT ANSWER IS: D

16. Refer to the Fluid Mechanics section of the *FE Reference Handbook.*

Units of absolute dynamic viscosity (μ) are kg/(m·s).

Units of kinematic viscosity (v) are m^2/s.

$\therefore$ The relationship between the two is:

$v = \mu/\rho$ where ρ is the density in kg/m^3.

$v = 1.5/1.263(1{,}000) = 0.001188 = 1.19 \times 10^{-3}$.

THE CORRECT ANSWER IS: A

17. Refer to the Fluid Mechanics section of the *FE Reference Handbook.*

THE CORRECT ANSWER IS: D

48. The mean pressure of the fluid acting on the gate is evaluated at the mean height, and the [illegible] of pressure is 2/3 of the height from the top; thus, the total force of the fluid is:

$$F_f = \rho g \frac{H}{2}(H) = 1,600(9.807)\frac{3}{2}(3) = 70,610 \text{ N}$$

and its point of application is 1.00 m above the hinge. A moment balance about the hinge gives

$$F(3) - F_f(1) = 0$$

$$F = \frac{F_f}{3} = \frac{70,610}{3} = 23,537 \text{ N}$$

THE CORRECT ANSWER IS: C

49. Use the rational formula.

$$Q = CIA$$

$$Q = (0.10)(1.5 \text{ in./hr})(20 \text{ acres}) = 3.0 \text{ cfs}$$

THE CORRECT ANSWER IS: A

50. $$h_L = f\left(\frac{L}{D}\right)\left(\frac{v^2}{2g}\right)$$

$$h_{L,AB} = 0.03\left(\frac{200}{2}\right)\left(\frac{2^2}{2\times 32.2}\right) = 0.03(100)(0.062) = 0.186 \text{ ft}$$

$$h_{L,AC} = 0.03\left(\frac{200}{3}\right)\left(\frac{1.3^2}{2\times 32.2}\right) = 0.03(67)(0.026) = 0.052 \text{ ft}$$

$$h_{L,CB} = h_{L,AB} - h_{L,AC} = 0.186 - 0.052 = 0.134 \text{ ft}$$

Since the head loss from A to B is larger than the head loss from A to C, the head at C is greater than the head at B. This means there is flow from C to B.

THE CORRECT ANSWER IS: B

51. $$H_L = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right)$$

For the same piping system and velocity, H_L is proportional to f. For this case, the Reynolds number is very large, corresponding with fully turbulent flow conditions. Referring to the Moody Stanton Diagram in the Fluid Mechanics section of the *FE Reference Handbook*, it is apparent that f depends on pipe roughness but not Reynolds number for $\varepsilon/D = 0.001$ and Reynolds numbers $>10^6$. Thus, $f \cong 0.02$ for both applications, and pressure drops are equal.

THE CORRECT ANSWER IS: A

52. $$A = \frac{\pi(2.5)^2}{4} = 4.91 \text{ ft}^2$$

$$R = \frac{D}{4} = \frac{2.5}{4} = 0.625 \text{ ft}$$

$$S = \frac{105 - 103.5}{400} = 0.00375$$

$$Q = \frac{1.486}{0.013}(4.91)(0.625)^{2/3}(0.00375)^{1/2}$$

$$Q = 25.12 \text{ cfs}$$

THE CORRECT ANSWER IS: B

53. Elevation difference:

112 – 78 = 34 ft

THE CORRECT ANSWER IS: B

54. Pressure difference between the sixth floor and ground level

$$= \left(\frac{62.4 \text{ lb}}{\text{ft}^3}\right)\left(6 \text{ floors} \times \frac{12 \text{ ft}}{\text{floor}}\right)\left(\frac{1 \text{ ft}^2}{144 \text{ in}^2}\right) = 31.2 \text{ psi}$$

Pressure on sixth floor = 85 – 31.2 = 53.8 psi

THE CORRECT ANSWER IS: B

55. Solve for h.

$10 \text{ ft/sec} = 1.318 \times 150 \times (12/12/4)^{0.63}(h/9{,}000 \text{ ft})^{0.54}$

Solve for h.

$10 = 82.5\ (x/9{,}000)^{0.54}$

$h = 180.7$

THE CORRECT ANSWER IS: C

56. $Q = CIA$

$$A = \frac{Q}{CI} = \frac{10}{0.65 \times 6.8} = 2.26 \text{ acres}$$

Catchment Area = $2.26 \text{ acres} \times 43{,}560 \text{ ft}^2 / \text{acre} = 98{,}400 \text{ ft}^2$

$A = 100 \times L$

$$L = \frac{98{,}400}{100} = 984 \text{ ft}$$

THE CORRECT ANSWER IS: A

17. Apply a downward 1-kip load (unit load) at Joint C and compute forces f in bars. (This can easily be done by dividing each F force by 40).

Multiply each member's change in length $\Delta L = \frac{FL}{AE}$ by its force f in the table below (be sure to use the signed values of $\Delta L = \frac{FL}{AE}$ and f).

Then, sum $f \cdot \frac{FL}{AE}$ to get the displacement at Joint C.

$\sum f \cdot \frac{FL}{AE} = +1.0464$ in. down

Member	F (kips)	L (in.)	$\frac{FL}{AE}$	f	$f \cdot \frac{FL}{AE}$
AB	50.0	240	0.1034	1.25	0.1292
BC	49.2	473	0.2008	1.231	0.2472
CD	–75.0	480	–0.3103	–1.875	0.5818
AD	–30.0	288	–0.0745	–0.75	0.0559
BD	–25.0	240	–0.0517	–0.625	0.0323
					$\sum = 1.0464$

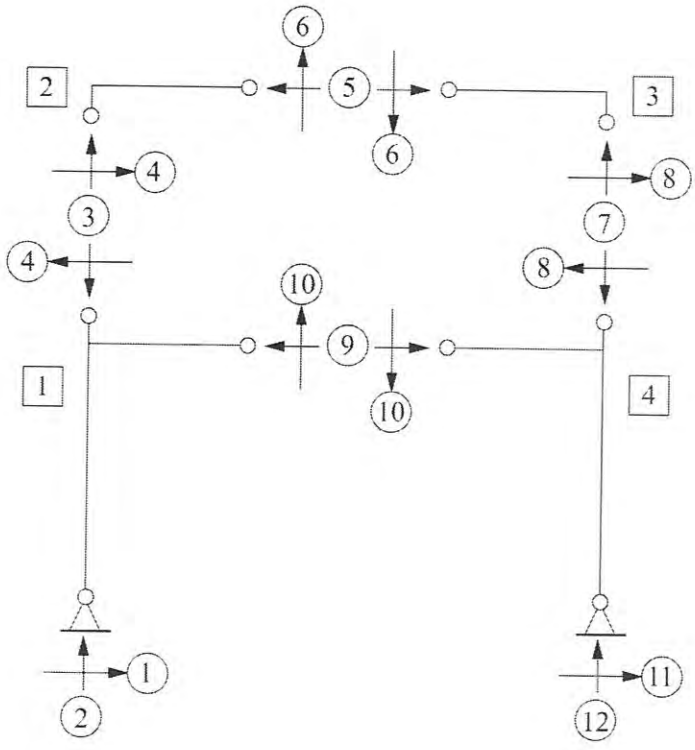
THE CORRECT ANSWER IS: A

58. Unknown reactions and internal forces at internal pins: $6 \times 2 = 12$

Rigid body components (shown as FBDs) @ 3 equations per component: 4

Number of equations: $4 \times 3 = 12$

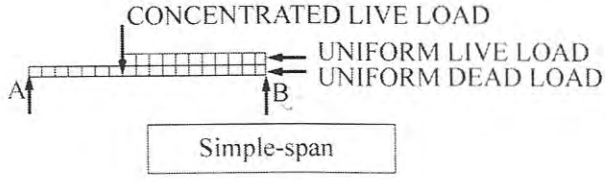
There are 12 equations and 12 unknowns → determinate (stable by member arrangement).



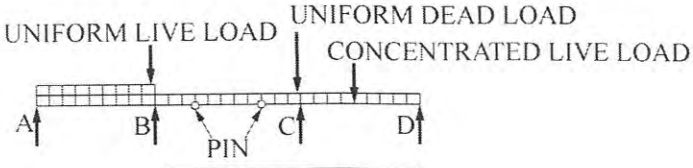
[1] RIGID BODY

(1) UNKNOWN FORCE

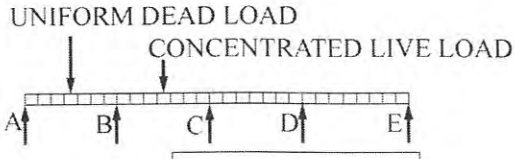
THE CORRECT ANSWER IS: B



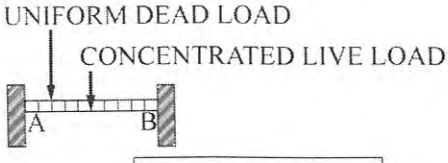
Simple-span



Multispan



Indeterminate

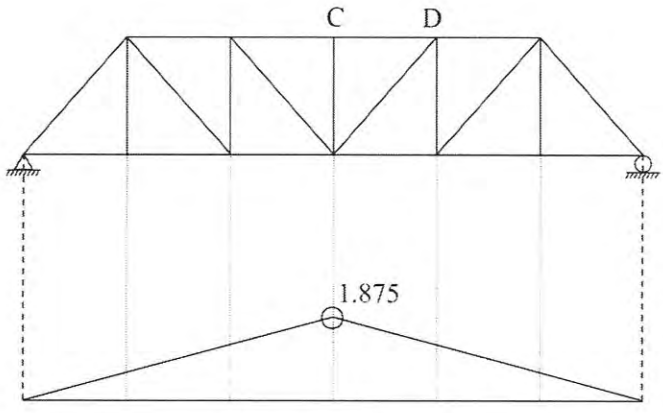


Fixed-end

THE CORRECTLY LABELED BEAMS ARE SHOWN ABOVE.

60. The maximum force in CD occurs when the wheel is placed at the location that corresponds to the peak of the influence line:

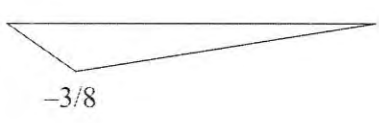
Max $F_{CD} = 1.875 \times 20 \text{ kips} = 37.5 \text{ kips}$



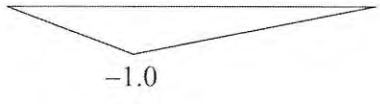
Influence line for CD

THE CORRECT ANSWER IS: C

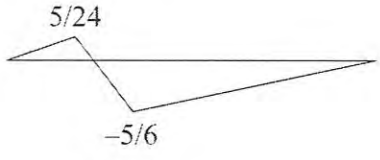
61. (A)



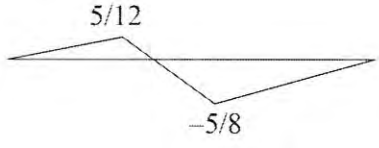
(B)



(C)



(D)



THE CORRECT ANSWER IS: B

61. By definition of a cantilever beam, it is **not** statically indeterminate, it is completely supported, and it is loaded only at a specific point.

THE CORRECT ANSWER IS: A

62. **Method 1 (computation)** For bracing @ $L/3$: $L_b = 10.0$ ft and $C_b = 1.0$ (given)

From the Z_x table in the Civil Engineering section of the *FE Reference Handbook*, for W21 × 57: $\phi M_p = 484$ ft-kips $L_p = 4.77$ ft $L_r = 14.3$ ft BF = 20.1

Since $L_p < L_b = 10 < L_p$:

$\phi M_n = \phi M_p - \text{BF} \times (L_b - L_p) = 484 - 20.1 \times (10.0 - 4.77) = 378.9$ ft-kips

$$w_u = \frac{8\phi M_n}{L^2} = \frac{8 \times 378.9}{(30)^2} = 3.368 \text{ kips/ft}$$

Method 2 (graphical) For bracing @ $L/3$: $L_b = 10.0$ ft and $C_b = 1.0$ (given)

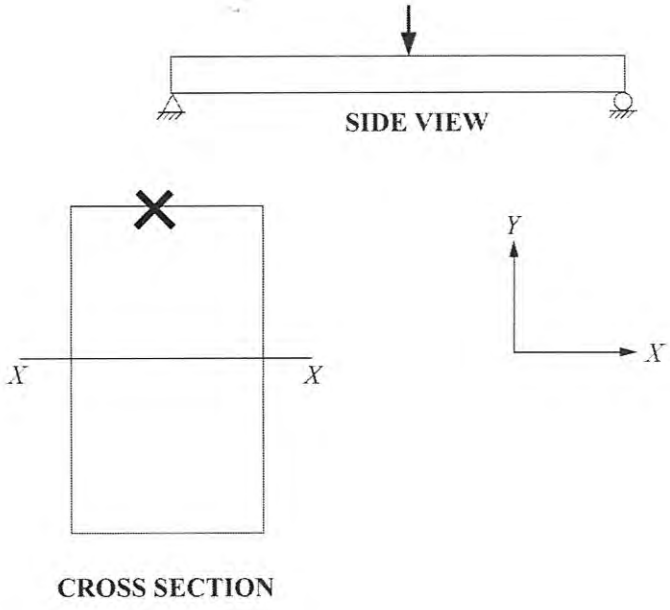
From the Beam Design Moments curves in the Civil Engineering section of the *FE Reference Handbook*:

Enter horizontal axis at $L_b = 10.0$ ft, and read upward to W21 × 57 curve: $\phi M_n = 378$

$$w_u = \frac{8\phi M_n}{L^2} = \frac{8 \times 378}{(30)^2} = 3.360 \text{ kips/ft}$$

THE CORRECT ANSWER IS: B

64. Maximum normal stress in a beam due to transverse loading will be located at the outermost fiber.



CROSS SECTION

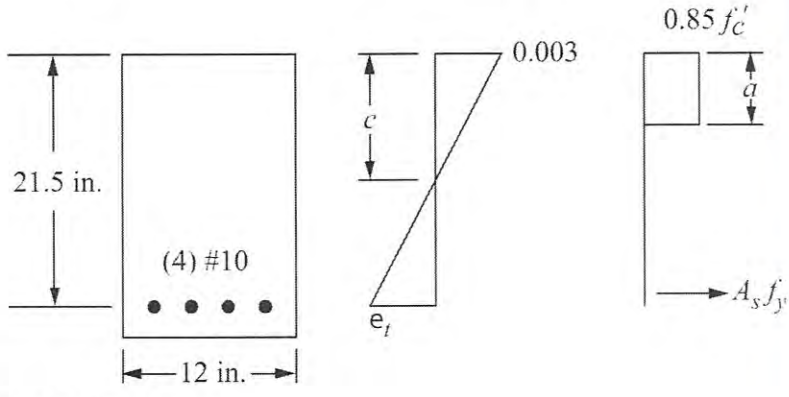
THE CORRECT ANSWER IS MARKED ABOVE.

65. $A_s = 5.08 \text{ in}^2 \text{(given)}$

$$a = \frac{5.08(60)}{0.85(4)(12)} = 7.47 \text{in.}$$

$$c = \frac{a}{\beta_1} = \frac{7.47}{0.85} = 8.79 \text{ in.}$$

$$d_t - c = 21.5 - 8.79 = 12.71 \text{ in.}$$



$$\varepsilon_t = \frac{d_t - c}{c}(0.003) = \frac{12.71}{8.79}(0.003) = 0.004338 \text{ in./in.}$$

Since $0.004 < \varepsilon_t < 0.005$, compute ϕ:

$$\phi = 0.48 + 83(0.004338) = 0.84004 = 0.84$$

THE CORRECT ANSWER IS: C

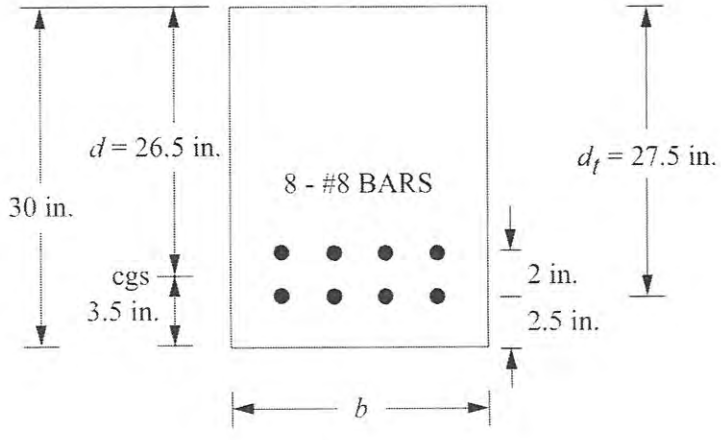
$$M_n = \frac{M_u}{\phi} = A_s f_y \left(d - \frac{a}{2} \right) = A_s f_y \left(d - \frac{1}{2} \times \frac{A_s f_y}{0.85\, f_c' \, b} \right)$$

where $A_s = 8 \times 0.79 \text{ in}^2 = 6.32 \text{ in}^2$

$d = 30 - 3.5 = 26.5$ in. (do not use $d_t = 27.5$ in.)

$$\frac{648 \times 12}{0.9} = 6.32 \times 60 \left(26.5 - \frac{1}{2} \times \frac{6.32 \times 60}{0.85 \times 4 \times b} \right)$$

$b = 14.98$ in. (use 15 in.)



THE CORRECT ANSWER IS: D

67. $d = 18$ in.

$A_s = 3(1.27) = 3.81 \text{ in}^2$

$$a = \frac{A_s f_y}{0.85 f_c' b} = \frac{3.81\,(60)}{0.85\,(4)(14)} = 4.80 \text{ in.}$$

$$M_n = A_s f_y (d - a/2) = 3.81(60)(18 - 4.8/2)/12 = 297 \text{ ft-kips}$$

$$E_s = E_c\left(\frac{d-c}{c}\right) = 0.003\left(\frac{18 - 4.8/0.85}{4.8/0.85}\right) = 0.0066 > 0.005$$

$\therefore \phi = 0.9$

$\phi M_a = 0.9(297) = 267$ ft-kips

THE CORRECT ANSWER IS: A

68.

d = 20 in. $\quad A_s = 4\pi(1)^2/4 = 3.14 \text{ in}^2$

$$a = \frac{A_s f_y}{0.85 f_c' b} = \frac{3.14\,(60)}{0.85\,(4)(16)} = 3.46 \text{ in.}$$

$M_n = A_s f_y (d - a/2)$

$= 3.14(60)(20 - 3.46/2) = 3,443$ k·in.

3,443 k·in. × 1 ft/12 in. = 286.9 k·ft

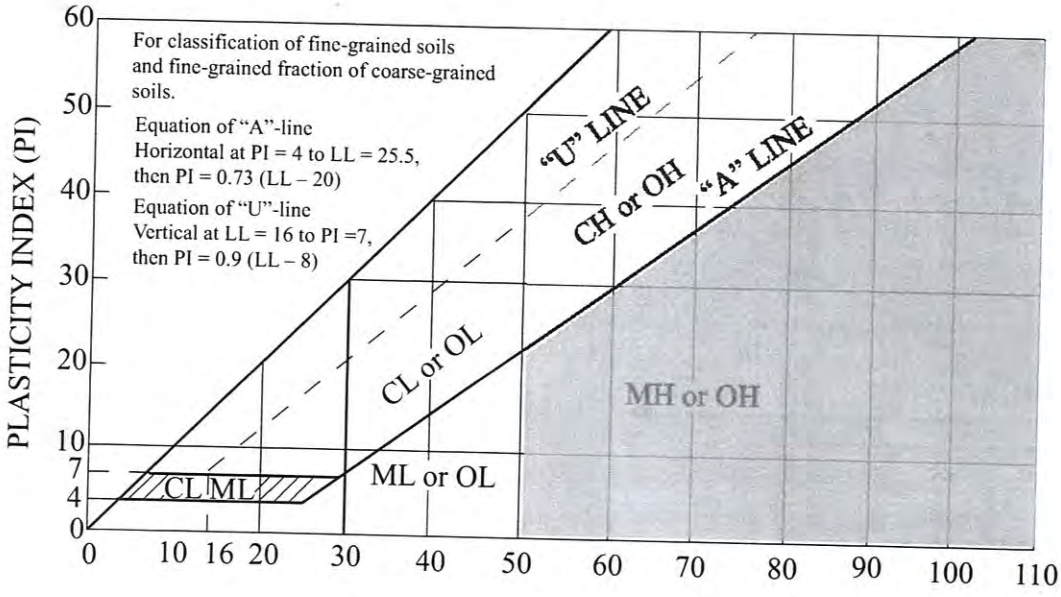
$$E_s = E_c\left(\frac{d-c}{a}\right) = 0.003\left(\frac{20 - 3.46/0.85}{3.46/0.85}\right) = 0.012 > 0.005 > E_y$$

$\therefore \phi = 0.9$

$\phi M_n = 0.9(286.9) = 258$ ft·kips

THE CORRECT ANSWER IS: A

69. MH stands for an elastic silt. Anywhere below the A-line and to the right of the LL = 50 line will satisfy this condition.



THE CORRECT ANSWER IS SHADED ABOVE.

70. $Gw = Se$

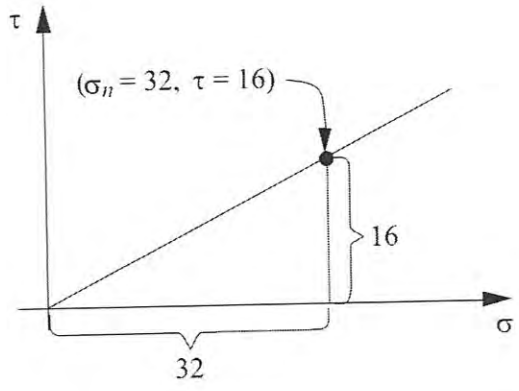
$(2.7)(0.105) = S(0.63)$

$S = 45\%$

THE CORRECT ANSWER IS: B

71. $\sigma_n = \dfrac{N}{A} = \dfrac{512 \text{ lb}}{16 \text{ in}^2} = 32 \text{ psi}$

$\tau = 16$ psi



$\phi = \tan^{-1}\left(\dfrac{16}{32}\right) \cong 27°$

THE CORRECT ANSWER IS: B

72. $\sigma' = \sigma - u = (135 \times 10) - 62.4\ (10) = 726$ psf

THE CORRECT ANSWER IS: B

73. $K_p = \tan^2\ (45 + 30/2) = \tan^2\ (60) = (1.732)^2 = 3.0$

$P_p = 0.5 \times \gamma \times H^2 \times K_p = 0.5\ (125)\ (12 \times 12)\ (3) = 27{,}000 \text{ lb/ft}^2$

THE CORRECT ANSWER IS: D

74. Refer to the *FE Reference Handbook.*

$q_{ult} = cN_c + \gamma D_f N_q + 0.5\,\gamma B N_\gamma$

Since $N_c = 0$ and $D_f = 0$,

$q_{ult} = (0.5)(120)(2)(25)$
$= 3{,}000$ psf

THE CORRECT ANSWER IS: C

75. $t = T H_{dr}^2/c_v = 1.2\,(5 \times 5)/0.16 = 187.5$ days

THE CORRECT ANSWER IS: C

76. From the *FE Reference Handbook*:

$$Q = kH\left(\frac{N_f}{N_d}\right) \text{(for flow nets, } Q \text{ per unit width)}$$

k = 0.0004 in./sec

H = 50 ft

N_f = Number of flow channels ≈ 3.5

N_d = Number of drops = 8

L = Wall length = 600 ft

$$Q = \left(0.0004\frac{\text{in.}}{\text{sec}} \times \frac{1\text{ ft}}{12\text{ in.}}\right)(50\text{ ft})\left(\frac{3.5}{8}\right) = \left(0.000729\text{ ft}^3/\text{sec per ft of wall length}\right)$$
$$\times\left(3{,}600\frac{\text{sec}}{\text{hr}}\right)\left(24\frac{\text{hr}}{\text{day}}\right)$$
$$= 63\text{ ft}^3/\text{day per ft of wall length}$$

$$\text{Seepage} = Q \times L = \left(63\text{ ft}^3/\text{day per ft of wall length}\right)(600\text{ ft}) = 37{,}800\text{ ft}^3/\text{day}$$

THE CORRECT ANSWER IS: B

77. $\text{PVC} = \text{PVI} - L/2 = 30{+}00 - \dfrac{8}{2}$ Sta. $= 26{+}00$

$$\text{Elev. of PVC} = \text{Elev. PVI} - g_1 \times \frac{L}{2} = 200 - (-6) \times \frac{8}{2} = 224.00 \text{ ft}$$

For Station 31+00: $x = 31{+}00 - 26{+}00 = 5$ stations

$$\text{Curve elevation} = Y_{PVC} + g_1 x + [(g_2 - g_1)/(2L)]\, x^2$$

$$= 224.00 + (-6) \times 5 + [(4) - (-6) / (2 \times 8)] \times 5^2$$

$$= 209.63 \text{ ft}$$

THE CORRECT ANSWER IS: B

78. Try equation for $S \leq L$

$$L = \frac{AS^2}{100\left[\sqrt{2h_1} + \sqrt{2h_2}\right]^2}$$

$$= \frac{9 \times 600^2}{100\left[\sqrt{2 \times 3.50} + \sqrt{2 \times 1.00}\right]^2}$$

$$= 1{,}966 \text{ ft}$$

$S \leq L$ as assumed. Therefore, the correct equation was used.

THE CORRECT ANSWER IS: B

79. $T = R \tan (I/2) = 600 \times \tan \dfrac{40.8333°}{2} = 223.34$

$$L = RI \frac{\pi}{180} = 600 \times 40.8333° \times \frac{\pi}{180} = 427.61$$

$PC = PI - T = 20{+}00.00 - 223.34 = 17{+}76.66$

$PT = PC + L = 17{+}76.66 + 427.61 = 22{+}04.27$

THE CORRECT ANSWER IS: B

80. Departure sight triangles are based on a vehicle stopped at the stop bar and looking at major street vehicles for acceptable gaps.

THE CORRECT ANSWER IS: B

81. $2.50 = 0.44(2) + 0.25(4) + 0.10(D_3)$

$$D_3 = \frac{2.50 - 0.88 - 1.00}{0.10} = \frac{0.62}{0.10} = 6.2 \text{ in.}$$

THE CORRECT ANSWER IS: C

82. Asphalt or any combination with asphalt will be thicker under identical conditions.

THE CORRECT ANSWER IS: C

83. Crash factors are not additive, so combined CR

$CR = CR_1 + (1 - CR_1)\, CR_2$ (order CRs from highest to lowest)
$= 0.25 + (1 - 0.25)0.15$
$= 0.36$

1 since no change in ADT

Crashes prevented $= N \times CR \left(\frac{\text{ADT after}}{\text{ADT before}} \right)$

$3.6 = 10 \times 0.36$
$10 - 3.6 = 6.4$

THE CORRECT ANSWER IS: D

84. $$\text{Distance} = \frac{V^2}{30\left[(a/32.2) \pm G\right]} + 1.47Vt;\ a = f(32.2)$$

$$= \frac{50^2}{30[0.65 - 0.10]} + 1.47(50 \times 1.5)$$

$$= 151.52 + 110.25$$

$$= 261.8$$

THE CORRECT ANSWER IS: D

85. $$\text{Spacing} = \frac{3{,}600 \text{ sec/hr}}{1{,}400 \text{ vehicles/hr}} = 2.57 \text{ sec/vehicle}$$

THE CORRECT ANSWER IS: A

86. WALK + width/pedestrian speed – yellow = green

6 + 12.5 – 3.5 = 15.0

THE CORRECT ANSWER IS: B

87. Refer to the Chemistry section of the *FE Reference Handbook* for the equilibrium constant of a chemical reaction.

$4A + B \leftrightarrow 2C + 2D$

THE CORRECT ANSWER IS: D

88. $\text{Residence time} = \dfrac{\text{volume}}{\text{flow rate}}$

$$\text{Clarifier volume} = 2 \times \left[\pi \frac{(65\text{ ft})^2}{4} (12\text{ ft}) \right] = 79{,}639\text{ ft}^3$$

$$\text{Flow} = \left(\frac{5\text{ MGD}}{7.48\text{ gal/ft}^3} \right) \left(\frac{10^6\text{ gal/Mgal}}{24\text{ hr/day}} \right) = 27{,}852\text{ ft}^3\text{/hr}$$

$$\text{Residence time} = \frac{79{,}639\text{ ft}^3}{27{,}852\text{ ft}^3\text{/hr}} = 2.86\text{ hr}$$

THE CORRECT ANSWER IS: C

89. 2 moles of As × 75 g/mole of As = 150 g of As

THE CORRECT ANSWER IS: C

90. $V = (100\text{ ft}^2)(15\text{ gpm/ft}^2)(12\text{ min})$

$= 18{,}000\text{ gal}$

THE CORRECT ANSWER IS: C

91. $BOD_5 = 200\text{ mg/L}$
$\therefore\ t = 5\text{ days}$
$k_1 = 0.23\text{ day}^{-1}$

$$BOD_t = BOD_{ult}\left(1 - e^{-k_1 t}\right)$$

$$200\text{ mg/L} = BOD_{ult}\left(1 - e^{-0.23 \times 5}\right)$$

$$BOD_{ult} = 200 / \left(1 - e^{-1.15}\right)$$

$$BOD_{ult} = 292.7\text{ mg/L}$$

THE CORRECT ANSWER IS: C

92. The balanced equation is: $C_6H_6 + 7.5O_2 \rightarrow 6CO_2 + 3H_2O$

$$500 \text{ mg/L Bz}\left(\frac{1 \text{ mmole Bz}}{78 \text{ mg Bz}}\right)\left(\frac{7.5 \text{ mmole } O_2}{\text{mmole Bz}}\right)\left(\frac{32 \text{ mg } O_2}{\text{mmole } O_2}\right) = 1{,}540 \text{ mg/L}$$

THE CORRECT ANSWER IS: D

93. **THE CORRECT ANSWER IS: C**

94. Time to load one truck = 15 yd^3/3 yd^3/min
= 5 min

Four trucks are available.
Cycle time for one truck = 5 min loading plus 12 min to travel, dump, and return = 17 min.
Loading time for four trucks = 4 × 5 = 20 min.

Therefore, an empty truck is always available to load.

$$\text{Ideal production capacity} = \left(\frac{60 \text{ min/ hr}}{5 \text{ min/ truck}}\right)\left(15\frac{\text{yd}^3}{\text{truck}}\right)$$

$$= 180\frac{\text{yd}^3}{\text{hr}}$$

THE CORRECT ANSWER IS: A

95. Production of Excavator 3 $= \dfrac{60 \text{ min/hr}}{0.50 \text{ min cycle}} \times 1.75 \text{ LCY capacity} = 210 \text{ LCY/hr}$

Similar calculations for the other three excavators show they have lower production rates.

THE CORRECT ANSWER IS: C

96. Dry unit weight of embankment material $= 122\left(\frac{100}{116.7}\right)$

$= 104.5$ pcf

$= \frac{104.5}{106}(320{,}000)$

$= 315{,}470\ \text{yd}^3$

THE CORRECT ANSWER IS: B

97. Use Law of Cosines

$a^2 = b^2 + c^2 - 2bc \cos A$

$\cos A = \frac{480^2 + 720^2 - 390^2}{z(480)(720)}$

$A = 30° 18' 47"$

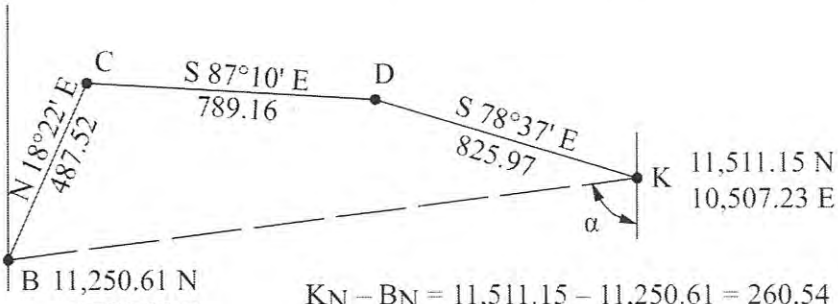
THE CORRECT ANSWER IS: A

98. Refer to Earthwork Formulas in the Civil Engineering section of the *FE Reference Handbook.*

Volume to be excavated = $130[322 + (4)(395) + 418]/[(6)(27)] = 1{,}862\ \text{yd}^3$

THE CORRECT ANSWER IS: C

99.



$K_N - B_N = 11{,}511.15 - 11{,}250.61 = 260.54$

$K_E - B_E = 10{,}507.23 - 8{,}755.32 = 1{,}751.91$

Sta	Distance (L)	Bearing (θ)	Lat (N) (L cos θ)	Dep (E) (L sin θ)	Coordinates	
					E (X)	N (Y)
B					8,755.32	11,250.61
	487.52	N 18°22' E	+462.69	+153.62		
C					8,908.94	11,713.30
	789.16	S 87°10' E	–39.01	+788.20		
D					9,697.14	11,674.29
	825.97	S 78°37' E	–163.02	+809.72		
K					10,507.23	11,511.27
	2,102.65					

Δ Lat = 11,511.27 – 11511.15 = 0.12

THE CORRECT ANSWER IS: A

100. Find the area of the fractional part of the circle.

$A = \pi r^2$

$A = \pi(500)^2$

Fraction of circle $= \dfrac{36°48'}{360°} = \dfrac{36.8°}{360°} = 0.1022$

Area of fraction of circle $= 0.1022 \times \pi \times (500)^2 = 80,285 \text{ ft}^2$

Shaded area = total area – fraction of circle

$= 83,164 - 80,285$

$= 2,879 \text{ ft}^2$

THE CORRECT ANSWER IS: A