**ASTB Study Topics (OAR Only)**

**Tips for Taking the ASTB**

1. Approach the exam with confidence. This is arguably the most important factor that will affect you during the exam. Without feeling confident before beginning the exam, it does not matter how much you’ve studied, your efforts will be in vein as you’ve already limited yourself while feeling unconfident and unworthy of a good score.

2. Take ALL the practice tests from all the major book publishers and know how to do EVERY problem on each exam. If you cannot pass each exam with a perfect score in the allotted time, DO NOT take the actual ASTB! Continue to practice until you’re familiar with all the exam questions and can do them without running out of time.

3. Take the AFOQT, (for Air Force officers), and ASVAB, (for enlisted) practice exams, paying close attention to the math sections. These questions are similar to the practice material for the ASTB.

4. Answer all questions when taking the actual ASTB. There are no penalties for a wrong answer!

- Best of luck on your exam!

**Math**

- **Units**
  - 12 Inches = 1 Foot
  - 4 Quarts = 1 Gallon
  - 8 Ounces = 1 Cup
  - 3 Feet = 1 Yard
  - 16 Ounces = 1 Pound
  - 2,000 Pounds = 1 Ton
  - 8 Pints = 1 Gallon
  - 144 Square Inches = 1 Square Foot ($12^2$)
  - To calculate cubic feet multiply length x width x height.

- **Powers and Roots (Memorize)**
  - Powers of 2: 1, 4, 9, 16, 25, 36, 49, 64, 81, 100, 121, 144, 169

- **Formulae**
  - (# of sides - 2) x 180 = Total # of degrees
  - Distance formula: $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$

- **Miscellaneous Problems and Techniques**
  - A naval detachment has enough rations to feed sixteen people for 10 days. If four more people join the detachment, how many fewer days will the rations last?
    - Always use amount x time = amount x time for these problems.
    - 16 x 10 = 20 x X
    - 160 = 20x, x = 8 days.
    - 10 - 8 = **2 days less**.
  - **Technique**: Plug in numbers to find the answer
    - Simplify $N + 6N^2 / 6N + 1$
    - Either simplify this problem yourself, or simply plug in a number on your own. We’ll use 1. If we plug in 1 for N, we get $7/7 = 1$.
    - Thus, $N = 1$, or $N$. 

Technique: An easy way to multiply large, whole numbers such as 800 x 300 is to multiply 8 x 3, (24), than add on the number of zeros from 800 and 300 (4 zeros total). The answer will be 240,000.

Technique: pi is 3.14 or 22/7.

Assume that it takes an average of 3 man-hours to stack 1 ton of a particular item. In order to stack 36 tons of that item in 6 hours, the number of persons required is
- If it takes 3 man hours to stack 1 ton of items, than it will take (3 x 36), or 108 man hours to stack 36 tons of items. To do this in 6 hours, divide the total number of man-hours by 6 to get 18 men.

Percent Problems
- Successive Discounts
  - Successive discounts of 20 percent and 15 percent are equivalent to a single discount of?
    - 100 x 20% = 20.
    - 100 – 20 = 80.
    - 80 x 15% = 12. 80 – 12 = 68.
    - 100 – 68 = 32.
  - A number x was increased by 4% the result being 17.16. What is x?
    - The number was increased by 4%, so 17.16 is 104% of the number. We want to find what 100% of the number is, so we can use a proportion.
      - 17.16/104 = x/100.
      - Solving for x we get 16.50

Ordering/Comparing Fractions
- Find a common denominator for all fractions and order the numerators.
- Or, simply cross multiply. The greatest product is the largest fraction.

Square Roots
- Find the square root of 729.
  - Choose any number, say 20, and divide 729 by 20 ignoring any remainders.
  - 729/20 = 36
  - Find the average of 20 and 36. 20 + 36 / 2 = 28.
  - Repeat the process until the estimate is the same as the quotient (until the remainder is 0).
  - 729 / 27 = 27.
  - √729 = 27.

Subtracting Feet and Inches
- 40 feet – 13 feet 2 inches
  - First subtract feet: 40 – 13 = 27.
  - Now subtract inches: rewrite: 26 feet 12 inches – 2 inches = 26 feet 10 inches.

Powers and Roots
- Multiplying powers with the same base number (always add)
  - X² • X³ = X⁵
- Raising a power to power (always multiply)
  - (X²)³ = X⁶
- Multiplying square roots
  - (3√5) • (7√2) = 21√10

Fraction Word Problems
- A patient's hospice stay cost one-fourth as much as his visit to the emergency room. His home nursing cost twice as much as his hospice stay. If his total healthcare bill was $140,000, how much did his home nursing cost?
Set up what you know: E = E, H = ¼E, N(nursing home) = 2H, or N = 2(1/4E) or N = ½E.
- E + H + N = 140,000.
- Get a common variable between all three: E + ¼E + ½E = 140,000.
- Solve for E, E = 80,000.
- Plug this number in for the cost of the nursing home, N = ½E, or N = 40,000.

- An automobile gasoline gauge reads 1/8 full. After the gas tank is filled with 15 gallons, the gauge reads 7/8 full. What is the capacity of the tank?
  - Subtract the amount of gas already in the tank from the amount filled. 7/8 – 1/8 = 6/8 or ¾.
  - ¾ of the capacity is equal to 15 gallons. 3/4 x = 15.
  - Solving for x... x = 20.

- A student spends ¾ of his money on tuition and 1/3 of what remains on books. If he has $50 dollars left, how much money did he start with?
  - First, find what amount of money remains after he spends his money on tuition, (1 – ¾ = ¼)
  - To find the amount spent on books, multiply 1/3 x ¼ = 1/12.
  - Add 1/12 + ¾ = 10/12 or 5/6 spent together.
  - To find WHAT REMAINS (he has $50 left), subtract 5/6 from 1. 1 – 5/6 = 1/6.
  - 1/6X = 50 X = 300

- It’s VERY important to subtract the amount of something from 1 to find the amount remaining. (Total amount – x is a very popular word problem technique).
  - A family budgets 1/3 of its income for rent, ¼ for food and 1/6 for clothing. If the family has $420 left, what is their monthly income?
    - 1/3 + ¼ + 1/6 = ¾
    - 1 – ¾ = ¼.
    - ¼ x = 420. Solving for x... x = 1680.

- Based on the following information, estimate the weight of a person who is 5'5" tall.

<table>
<thead>
<tr>
<th>Height</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>5'</td>
<td>110 lbs.</td>
</tr>
<tr>
<td>6'</td>
<td>170 lbs.</td>
</tr>
</tbody>
</table>

- The difference is 60 pounds. The trick here is to find the pounds per inch, so, 60/12 = 5 pounds per inch.
- If 5 pounds is equal to 1 inch, than 5 inches is equal to 25 pounds.
- Add 110 to 25 to get 135 pounds.

- Age Word Problems
  - A man is four times as old as his son. In 3 years, the father will be three times as old as his son. How old is each now?
    - For all age problems, it’s very important to realize that phrases such as, “the father is three times as old as his son”, involves multiplying the son’s age by three and not the father’s age, as confusing as this sounds.
    - Father’s age: 4X, son’s age: X
    - 4X + 3 = 3(X+3), Solving for X we get 6. Plug 6 back into the above expressions to get the father’s age: 24, son’s age: 6.

- Mixture Word Problems
  - This is the basic equation to use when dealing with mixture problems: Percent times amount plus percent times amount equals percent times amount.
A mixture containing 6% boric acid is to be mixed with 2 quarts of a mixture, which is 15% boric acid in order to obtain a solution, which is 12% boric acid. How much of the 6% solution must be used?

- Use the formula from the above bullet point. 0.06(x) + 0.15(2) = 0.12(x+2).
- **Technique**: Multiply by 100 on each side of the equation to get ride of the decimals.
- 6x + 30 = 12x + 24
- Solve for x and you will get 1 quart.

Acids can vary in strength, but water will always have 0% acid, thus water is always represented as 0, which always cancels the amount associated with it.

A chemist needs a solution of tannic acid that is 70% pure. How much distilled water must she add to 5 gallons of acid which is 90% pure to obtain the 70% solution?

- .9(5) + 0(x) = .7(5 + x)
- Solving for X, we get 10/7 or \(1\frac{3}{7}\).

### Motion, \((D = R \times T)\), Problems.

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- **Separation Situation** \((D_1 + D_2 = \text{Total Distance Apart})\)
  - Two cars leave a city going in opposite directions. One travels at 52 m.p.h. and the other at 84 m.p.h. How long until these two cars are 340 miles apart?
    - Add speeds: 52 + 84 = 136.
    - Divide distance by the total speed. 340/136 = **2.5 hours**.

- **Meeting Situation** \((D_1 + D_2 = \text{Total Distance Apart})\)
  - Two cars travel toward each other at the same time from cities 416 miles apart. The average rate of one car is 10 m.p.h. faster than the other car. If they pass each other in 4 hours, what is the average rate of each car?
    - \(D = R \times T\)
    - Dslower = 4s, Dfaster = 4s + 40.
    - 4s + (4s + 40) = 416
    - Solving for s... s = 47 and s + 10 = 57 (faster car)

- **Overtake Situation** \((D_1 = D_2)\)
  - A man leaves his home and jogs at 8 m.p.h. Fifteen minutes later, his wife leaves home and bikes after him at 11 m.p.h. How long after the wife leaves does she catch up with her husband?
    - The question asks for how long the wife will take to catch up with her husband, so we will use \(h = \text{wives’ time, and } h + \frac{1}{4}\) to denote the husband’s time (he leaves a quarter of an hour earlier, and is thus a quarter of an hour AHEAD of his wife).
    - Dwife = 11h, Dhusband = 8h + 2.
    - D1 = D2, 11h = 8h + 2. Solving for h... h = 2/3 or **40 min.**

A woman drives west at 45 miles per hour. After half an hour, a man starts to follow her. How fast must he drive to catch up to her three hours after he starts?

- 3.5 x 45 = r x 3
- 157.5 = 3r, \(r = 52.5 \text{ mph.}\)

- **Round-Trip Situation** \((D_{\text{out}} = D_{\text{back}})\)
  - A plane makes a round trip from San Francisco airport, which lasts 5 hours. If the average rate out is 200 m.p.h. and the average rate back is 300 m.p.h., what is the plane’s greatest distance from the airport?
    - \(H = \text{time flying OUT, and the time flying back is } 5 - h.\)
    - \(D = R \times T\), \(D_{\text{out}} = 200h, D_{\text{back}} = 300(5 - h).\)
    - \(D_{\text{out}} = D_{\text{back}}, 200h = 300(h - 5).\)
- Solving for h... h = 3 hours.
- Substitute 3 hours back into the equation for time OUT. Dout = 200h, 200 (3) = 600 miles.

**Other D = R x T Problems**
- Travis makes a 255-mile trip by car. He drives the first 2 hours at 45 miles per hour. At what speed must he travel for the remainder of the trip in order to arrive at his destination 5 hours after he started the trip?
  - First begin by finding the total distance he already traveled: 45 x 2 = 90 miles already traveled.
  - Subtract to 90 from 255 to find total distance needed to travel: 255 – 90 = 165 miles.
  - He already traveled 2 hours, and the question asks how long it will take him to travel the remaining distance 5 hours AFTER he started, so subtract 2 from 5 to get 3 hours.
  - \( D = R \times T, \) \( 165 = 3r \)
  - \( 165 / 3 = 55 \text{ miles per hour}. \)

**Work Problems**
- Individual Work Problems (Actual Time Worked / Total Time Required = 1), or, \( H_1 = \) time for person 1 to complete the job alone, \( H_2 = \) time for person 2 to complete the job alone, than we have \( T/H_1 + T/H_2 = 1 \)
  - One pipe can fill a tank in 8 minutes, another in 12 and another in 24 minutes. How long would it take all 3 pipes, working together to fill the tank?
  - \( H/8 + H/12 + H/24 = 1 \)
  - Solving for \( H \)... \( H = 4 \text{ minutes}. \)
- Two People Work Together than one Leaves
  - Fritz can build a bookcase in 8 hours and Holly can build it in 10 hours. After working together for 3 hours, Fritz leaves. How long will it take Holly to finish the bookcase by herself?
    - In 3 hours time, Fritz has completed \( 3/8 \) of the bookcase and Holly has completed \( 3/10 \). Fritz leaves, so Holly works alone at \( x/10 \).
    - \( 3/8 + 3/10 + x/10 = 1 \).
    - Solving for \( x \)... we get \( x = 3.25 \text{ hours}. \)
- One Person Works Alone than Another Person Joins in
  - Working alone, Allen can build a fence in 8 hours, and Danny can build the same fence in 16 hours. If after working alone for 2 hours, Allen is joined by Danny, how many more hours will it take the two of them to complete the fence?
  - Allen has worked two hours, so he has completed \( 2/8 \) of the job.
  - Danny joins him, so we will get: \( 2/8 + x/8 + x/16 = 1 \)
  - Solving for \( x \)... \( x = 4 \text{ hours}. \)

**Other Word Problems**
- What is the maximum number of boxes, each measuring 3 in x 4in x 5in, that can be packed into a storage space measuring 1 foot by 2 feet by 2 feet, 1 inch?
  - First convert feet to inches: 1 ft = 12 inches. 2 ft = 24 inches and 2ft 1in = 25 feet (24 inches + 1 inch).
  - The 3 inch edges will go in evenly into the 12 inch edge 4 times. \( 24/4 = 6 \), and \( 25/5 = 5 \).
  - Multiply \( 4 \times 5 \times 6 = 120 \).
- A lawn is 21 feet wide and 39 feet long. How much will it cost to weed and feed it if a gardening service charges $0.40 per square yard for this treatment?
  - First convert feet to yards. \( 3ft = 1yd. \) \( 21/3 = 7 \), \( 39/3 = 13 \).
Area of a rectangle is \( l \times w \). \( 13 \times 7 = 91 \). \( 91 \times 0.4 = \$36.40 \).

In a clothing factory, 5 workers finish production of 6 garments each per day, 3 others turn out 4 garments each per day, and one worker turns out 12 per day. What is the average number of garments produced per worker per day?

The key word in this problem here is EACH. First find the total number of garments: \( 5 \times 6 = 30 \), \( 3 \times 4 = 12 \), \( 1 \times 12 = 12 \). Add these together to get 54 total garments. Now divide this by the total number of workers. \( 54 / 9 = 6 \).

**Geometry**

**Angles**
- Complementary angles add up to 90 degrees.
- Supplementary angles add up to 180 degrees.
- Acute angle is less than 90 degrees.
- Obtuse angles are greater than 90 but less than 180.
- How many degrees are in an angle that is 20 degrees less than 4 times its supplement?
  - \( X = \) number of degrees in the angle we are looking for, \( (180 - x) = \) the number of degrees in the supplement of the angle.
  - \( X = 4(180 - x) - 20 \).
  - Solving for \( x \)... \( x = 140 \).
- Two supplementary angles are in the ratio of 3:7. How many degrees are in the smaller angle?
  - \( 3x = \) number of degrees in one angle and \( 7x = \) the number of degrees in the other.
  - \( 3x + 7x = 180 \). Solving for \( x \)... \( x = 18 \).
  - The smaller angle is \( 3x \) or \( 3(18) = 54 \) degrees.
- If the supplement of an angle is 3 times the complement of the same angle, how many degrees are in the angle?
  - \( 180 - x = 3(90 - x) \)
  - Solving for \( x \)... \( x = 45 \) degrees.
- Sum of Angles = \( (N - 2) \times 180 \). Where \( N = \) number of sides.
- Sum of the angles in a quadrilateral is 360 degrees. A quadrilateral has four sides.

**Perimeter**
- Perimeter of rectangle: \( P = 2L + 2W \).
- Perimeter of a square: \( P = 4s \).
- The perimeter of a rectangle is 50 ft. If the length of the rectangle is 4 more than twice its width, what are the dimensions of the rectangle?
  - \( X = \) width of the rectangle, and length \( = 2x + 4 \).
  - \( 50 = 2(2x + 4) + 2x \)
  - Solving for \( x \)... \( x = 7 \).
  - \( 2x + 4 = 18 \). Length is 18 and width is 7.
- A triangle has two equal sides. The third side has a length of 13 feet, 2 inches. If the perimeter of the triangle is 40 feet, what is the length of one of the equal sides?
  - Don't bother converting to inches, simply subtract feet and inches together: \( 40 \) feet \(- 13 \) feet \( 2 \) inches \( = 27 \) feet \(- 2 \) inches \( = 26 \) feet \( 10 \) inches.
  - Divide this by two to get the answer. 13 feet 5 inches.

**Area**
- Area of a rectangle: \( A = LW \)
- Area of a square: \( A = s^2 \)
- Area of a parallelogram: \( A = bh \)
- Area of a triangle: \( A = \frac{1}{2} bh \), or \( bh / 2 \).
- Area of a trapezoid: \( A = \frac{1}{2} (b_1 + b_2) \times h \)
- Circles
  - Circumference: \( C = \pi \times \text{diameter}, \text{or } 2 \times \pi \times r \).
  - Area: \( A = \pi \times r^2 \)
- Volume
  - Rectangular Solid: \( V = l \times w \times h \)
  - Cube: \( V = s^3 \)
  - Cylinder: \( V = \pi r^2 h \)
  - Pyramid: \( V = \frac{1}{3} l \times w \times h \)
- Surface Area
  - What is the surface area of a cube whose volume is 64 cu. Ft?
    - \( V = s^3, s = 4 \).
    - Area of a square = \( s^2, 4^2 = 16 \).
    - There are 6 sides to a cube, so \( 6 \times 16 = 96 \text{ sq. ft.} \)

**Mechanical Comprehension**

- **Mechanical Advantage**
  - MA is always equal to output force \( \div \) input force.
  - Questions that ask what the maximum weight can be under a given force must **MULTIPLY** the force by the system’s mechanical advantage.
    - If the rope on the end of a pulley system with a MA of 3 is pulled with 160 pounds of force, what is the maximum weight that can be lifted?
      - \( 3 \times 160 = 480 \text{ lbs.} \)
  - Questions that ask what force is necessary to move a weighted object must **DIVIDE** the weight by the system’s mechanical advantage.
    - A 240-pound block is being pulled up an incline by a pulley. The incline is 20 feet long and rises 5 feet. Neglecting friction, how much force is necessary to move the block up the incline?
      - MA of an incline plane = \( \frac{\text{length}}{\text{height}} = \frac{20}{5} = 4 \).
      - \( 240 / 4 = 60 \).

- **Principles and Laws**
  - **Bernoulli’s Principle**
    - The air pressure on top of an airplane wing is less than on the bottom of the wing.
    - The velocity of wind on top of the wing is greater than below the wing.
    - As the velocity of a fluid or gas increases, the pressure decreases.
  - **Boyle’s Law** (if temperature is held constant, inversely proportional)
    - The absolute pressure and volume of a gas are inversely proportional, as long as the temperature is held constant. If volume is halved, the pressure is doubled.
  - **Charles’ Law** (if pressure is held constant, directly proportional)
    - Gasses expand when heated. If the temperature on a gas is increased, the volume of the gas increases. Volume and temperature of a gas are directly proportional at a constant pressure.
  - **Newton’s Three Laws of Motion**
    - 1st: Every object in motion will stay in motion unless an outside force is applied to it.
    - 2nd: Force = Mass \( \times \) Acceleration (\( F = MA \)).
    - 3rd: Forces act in pair. A force acting on a body always elicits an equal, opposite force acting against it.
  - An airfoil creates more lift at lower altitudes with low humidity due to the density of the air being greater. This is called density altitude. Higher density altitude reduces aircraft performance.
The greatest amount of G-force is experienced going into and coming out of a loop.

Efficiency and Work
- Work\textsubscript{out} / Work\textsubscript{in}: This fraction can never be greater than 1.
- Work = Force \times Distance.

Basic Electricity
- Series Circuits (Christmas tree lights)
  - If any one part of the circuit is taken away, the electrical path is broken and will not work.
  - Current is constant throughout the circuit.
- Parallel Circuit
  - Has more than one electrical path.
  - If any one part is taken out, the circuit will continue to work.
  - Voltage across all elements is the same throughout the circuit.
- Ohm's Law (V = I \times R)
- No electricity passes through a burnt out light bulb.
- Current is constant in a series circuit, but voltage is not.
- Current \times \text{resistance} = \text{voltage}.

Buoyancy
- The force created by an object submerged in water is equal to the weight of water displaced by the volume of the object.

Gravity
- The rate of fall is the same, no matter what the weight of the object. Forward speed does not affect the speed of falling.
  - If a cannon fires a cannonball horizontally and you drop a cannonball at the same time, which will hit the ground first?
    - Answer: They will hit the ground at the same time.
- When a pendulum swings back, it does not go higher than the point where it started.
- The pendulum with the shorter string will swing faster than one with a longer string.
- If block A is suspended in the air by one rope, and block B is suspended in the air by 3 ropes, than the rope holding block A is under 3 times the tension in block B. Or, the ropes holding block B are under \(\frac{1}{3}\)rd the tension compared to the rope holding block A.

Levers
- **Mechanical advantage for levers**: Divide the length of effort arm by the length of load or resisting arm.
- Classes of levers:
  - First: Fulcrum is in the middle
    - Seesaw, scissors, pliers.
  - Second: Fulcrum is at one end, load is in between
    - Wheelbarrow, nut cracker,
  - Third: Fulcrum is at one end, effort is in between
    - Tweezers, tongs, fishing rod.
- Use this formula for lever problems: \(\text{Weight}_1 \times \text{Distance}_1 = \text{Weight}_2 \times \text{Distance}_2\).

Single level arm problems:
- In the figure above, the distance from A to B is 3 feet and the distance from B to C is 7 feet. How much force must be applied at A to lift the 50 lbs. at point B?
• Work the problem as you would any other lever problem: Weight_1 \times \text{Distance}_1 = \text{Weight}_2 \times \text{Distance}_2
  • The distance from A to C is 10 feet. 10 \times \text{Force} = 50 \times 7.
  • Solving for Force... = 35 \text{ lbs.}

☐ Belt Pulleys
  • Pulleys connected WITH a twisted belt move in opposite directions.
  • Pulleys connected WITHOUT a twisted belt move in the same direction.
  • Just as in gears, the smaller pulley in a set will turn the fastest, and the largest pulley will turn the slowest.

☐ Gears
  • Mechanical advantage for gears: # of teeth in the driven or load gear/# of teeth in the effort of driver gear.
  • Greater the difference in the # of teeth in each gear, the greater the torque (MA).
  • Formula for the number of revolutions in a gear: \( r = \frac{(D \times R)}{d} \), where \( r \): # of revolutions in gear A, d: # of teeth in gear A, R: # of revolutions in gear B, D: # of teeth in gear B.
    Or, \( r \times d = R \times D \).
  • Gears that are next to each other always turn in opposite directions.
  • With an odd number of gears, the first and the last will turn in the same direction.
  • With an even number of gears, the first and the last gears turn in opposite directions.
  • When two mated gears have an unequal number of teeth, the gear with fewer teeth will turn faster.
  • Gears with the same number of teeth will turn at the same speed, regardless of the number or size of the gears in-between them.
  • Internal gears turn in the same direction.
  • What is the RPM for a gear that has 8 teeth and makes two contacts a second?
    ▪ Two contacts a second = 120 contacts a minute (60 \times 2 = 120).
    ▪ 120/8 = 15 \text{ RPM}.

☐ Pulleys
  • Mechanical advantage in pulleys: the number of ropes supporting the weight. Only MOVEABLE pulleys provide mechanical advantage!
  • To find the force needed to lift a weight using pulleys: divide the weight by the number of sections of rope supporting it. Or, divide the weight by the MA.
  • To find the maximum weight that can be lifted given a specific force, multiply the mechanical advantage of the pulley system by the force.
  • If the MA is 4 in a pulley system, than for every 4 feet that is pulled, the weight will rise 1 foot.
    ▪ The greater the MA, the easier it is to lift a weight, but a greater length of rope is needed to pull it.
  • The tension in a rope is the reciprocal of the mechanical advantage.
  • Moveable pulleys rotate slower than fixed pulleys, and will only move up a fraction of the total distance of rope.
  • The mechanical advantage of a single fixed pulley is exactly 1.

☐ Pistons / Hydraulic Pressure
  • Pressure is the same in all areas of the hydraulic system, therefore, \( \text{Pressure}_1 = \text{Pressure}_2 \).
  • Pressure = Force / Area.
  • For all piston problems: \( \frac{a_2}{a_1} = \frac{d_1}{d_2} \) where a is the area and d is the vertical distance moved. (This can be used to find the mechanical advantage for pistons).
    ▪ Remember to multiply the mechanical advantage by the vertical distance moved by piston a to find the vertical distance moved by piston b!!
- **A x D = a x d**, where A and D are the larger areas and diameters, and a and d are the smaller.

- **Inclined Planes**
  - Mechanical advantage for an inclined plane: length of the ramp \( \div \) height of the ramp.
  - Smaller slope = greater MC, and less force needed to move an object up a ramp.
  - To find how much force is necessary to lift a weighted object up an inclined plane, find the mechanical advantage of the inclined plane, then **divide** the weight of the object by the mechanical advantage.

- **Wheel and Axel**
  - Mechanical advantage: The mechanical advantage (M.A.) for a wheel and axle is determined by dividing the diameter of the wheel by the diameter of the axle.

- **Fluids/Density**
  - An object will float on top of a liquid if its density is less than the liquid it is in and sink if its density is greater.
  - Surface has no effect on whether an object floats or sinks.

- **Thermodynamics**
  - Heat is transferred under these three methods:
    - Conduction – Occurs in solids or stationary fluids. The larger the temperature difference, the greater the amount of heat transfer. **Heat always flows from hot to cold.**
      - Good conductors: copper, silver, iron, steel.
      - Bad conductors (also called insulators): air, wood, paper, and cloth.
    - Convection – Occurs in gasses and liquids. Hotter air, (less dense), rises, while colder air (more dense), will sink under influence of gravity.
      - Water is warmer at the surface of a pool than at the bottom.
      - Hot air balloons.
    - Radiation – Electromagnetic waves that cause ionization and transfer heat when put in contact with an object.
      - The sun warms the earth.
      - A campfire emits radiation.
      - A light bulb.
      - A microwave.
  - Compressing air in a closed space will increase temperature and decrease space.
  - Heating a closed container will **INCREASE** the pressure, (pressure of tires in a car on a hot day vs. a cold day).
  - Adding salt to water increases the specific gravity of the solution and lowers its freezing point.

- **Spring Problems**
  - Two springs are arranged in a series, connected to a wall. Spring 1 is very stiff and stretches 1 inch for every 10 pounds applied to it. Spring 2 is less stiff and stretches 2 inches for every 5 pounds applied to it. How far will the springs stretch if a force of 20 pounds is applied?
    - Simply calculate how far each spring stretches under the given force and add them together:
      - Spring 1 stretches 2 inches. Spring 2 stretches 8 inches \((20/5 = 4 \times 2 = 8)\).
      - \(2 + 8 = 10\) inches.
  - A weight attached to two consecutive springs exerts a force of the weight onto each spring.

- **Pendulums**
  - Two pendulums with different weights that are hanging by the same length of string will take the same amount of time to make one swing.
Miscellaneous

- The speed of sound is 1126 feet per second.
- One unit of horsepower is equal to 33,000 ft-pound of work per minute.
- Power = Work / Time.
- Water flows faster through narrow areas than wider, but the same amount of water will flow in either case.
- Density = Mass / Volume
- Air is less dense at a higher altitude.

![Diagram of two boxes and wheels]

- In the figure above, Box A weighs 75 lbs. The radius of Wheel A is 6 feet and the radius of Wheel B is 2 feet. If both wheels are balanced, what must Box B weigh?
  - Box A creates a force of 75 x 6 = 450 pounds per foot. If the two boxes are level and equal, than the forces need to be equal.
  - 450 = 6x, x = 150 pounds.

![Diagram of a water wheel]

- In the figure above, the water wheel has a diameter of 9 feet. The flow of the river is 300 feet/minute. Approximately how many revolutions per minute is the water wheel turning and in what direction?
  - 300 / 28.26 = 10.6 revolution / minute.

![Diagram of a beam with forces]

- In the figure above, a 300-lb. force is applied to a bar supported at points A and B. The force is applied three feet from point A and seven feet from point B. The support at point B is a spring with a resistance of 15 lbs./inch. Determine how much the spring will be compressed in this configuration.
  - First find the force applied to point B. This involves first finding the force created at point A, which is 900 lbs., (Force x Distance = 300 x 3 = 900).
  - Now find the force applied to point B by adding the two distances (3 + 7 = 10), and dividing that by the 900 lbs. force created at point A. 90 pounds is applied to point B.
  - The resistance of the spring is 15 lbs./inch., so, 90/15 = 6 inches.