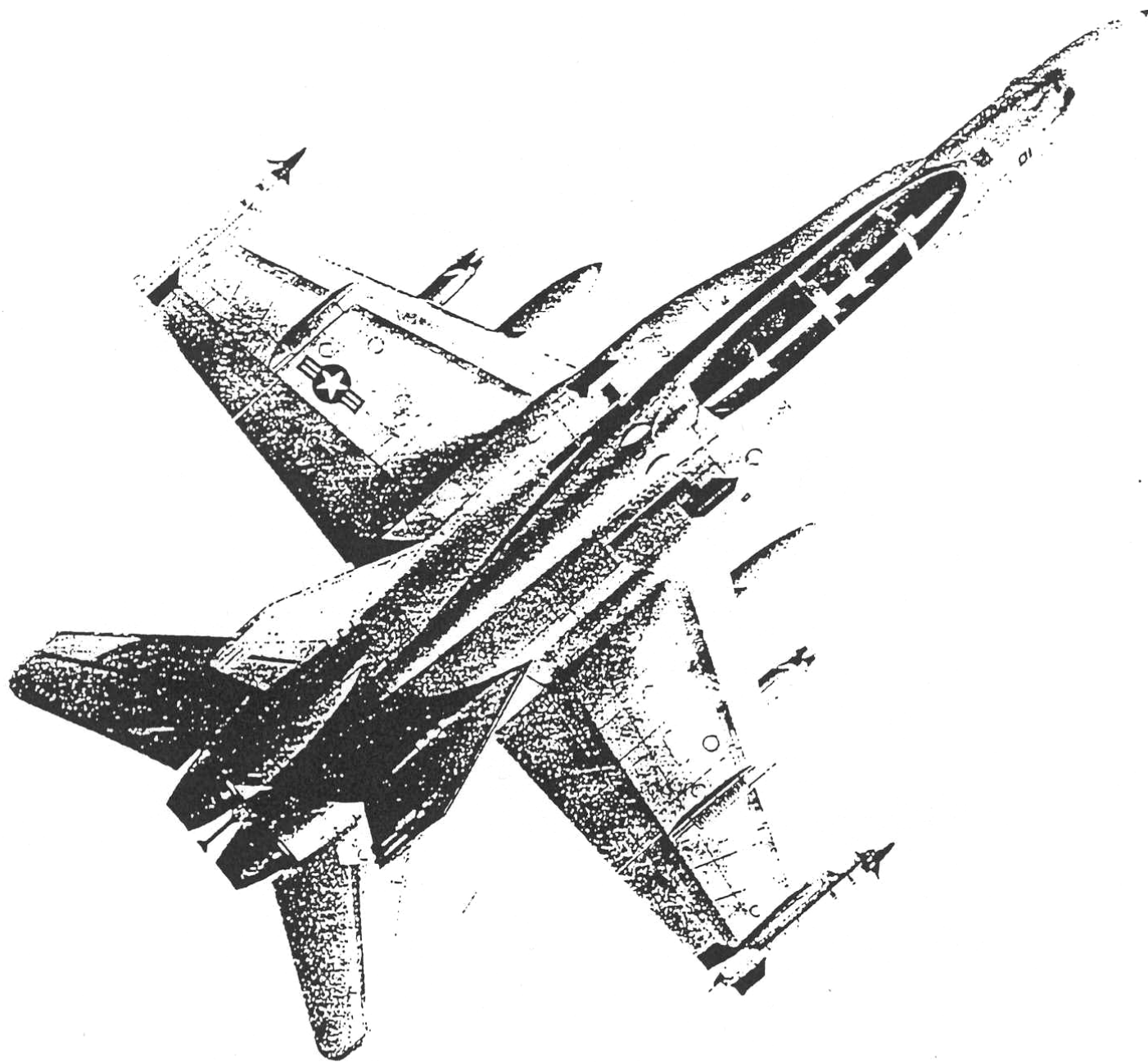


MARINE AVIATION GUIDEBOOK SUPPLEMENT



Introduction

The purpose of this supplement is to assist in your preparation for the aviation test. The focus is on mechanical comprehension as well as aviation knowledge. While the guidebook will give you an excellent variety of questions, this supplement should help you narrow down the seemingly endless amount of required aviation knowledge, and give you some insight to approach the majority of mechanical problems.

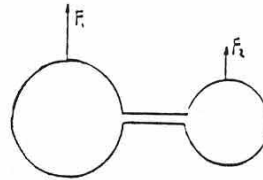
Many of the mechanical comprehension problems are of four types: gears, pulley systems, leverage, and inclined slope. These problems are similar in that they try to use a theoretical "mechanical advantage" to move weights or turn gears. The best way to approach the remaining problems is by trying them, checking your answers, and reading the explanations. Going through the problems one or two more times should narrow your questions to only a few problems.

The amount of aviation knowledge from which the test questions are selected compares to an entire ground school course! Fortunately, the questions are not very deep. In fact, if you read the information and then study the main concepts (which should be listed at the end of each chapter) you will do fine on the test. You need to start reading this material *weeks* before taking the test if you want enough time to study the other subjects. You need to acquire a book that teaches the fundamentals of aviation. Look for one that is offered in a ground school curriculum. There is no need to buy a private pilot test-prep book.

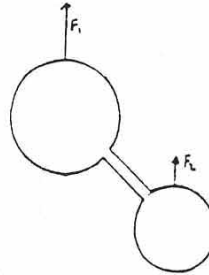
The following chapters are recommended: navigation, principles of flight, aircraft systems and performance, meteorology, and aviation and space history. You should also read the basics of naval history and understand what happens when entering or leaving supersonic speeds. Refer to the guidebook to see the types of questions that will be asked. If you feel confident after trying the questions in the guidebook, then read over only the sections that you have difficulty with.

· BUOYANCY

When an object is submerged in a fluid, a buoyancy force is created which acts upward and is equal to the weight of the fluid displaced by the volume of the object. In the following figure, the volume of the object is concentrated in the two spherical portions. Essentially we can imagine two unequal forces acting on the object.



The left sphere will experience a larger force than the right. This imbalance will make the left side move above the right sphere.



VELOCITY

$$\text{Velocity} = \text{Distance} / \text{Time}$$

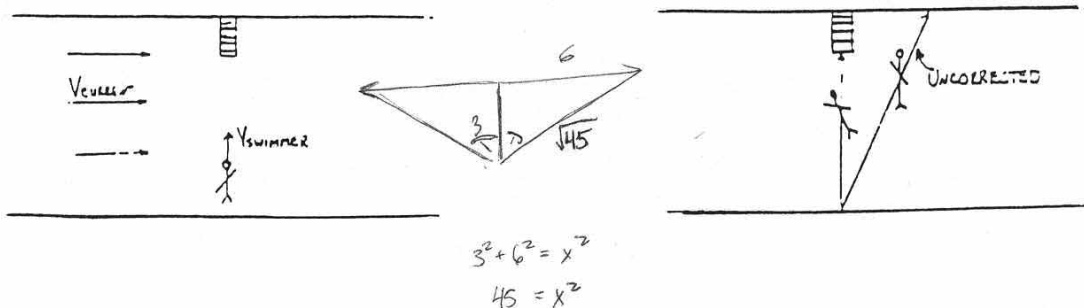
Velocity is the speed of an object moving in a certain direction. You need to know that velocities add. For example, you are on a train that is going 50 miles per hour and you begin to run towards the front at 5 mph. An observer standing on the ground sees you running 55 mph. If you were running towards the caboose, the velocity would be calculated as follows.

$$V = V_{\text{TRAIN}} + V_{\text{RUNNER}}$$

$$V = 50\text{mph} + (-5\text{mph})$$

$$V = 45 \text{ mph}$$

The next example involves the current in a river. The swimmer swims with a velocity of 3 mph pointing straight across. The river has a velocity of 6 mph downstream. The direction taken by the swimmer will not take him straight across. He must swim at an angle upstream in order to reach the dock. Aircraft that are dealing with cross winds turn into the wind to maintain a straight path over the ground or runway. This angle is called the crab angle.



: HYDRAULIC PRESSURE

Hydraulic machinery is used in aircraft, construction machinery and industry. Hydraulics use the same mechanical principles as levers, pulleys, and gears. That is, using a small force over a long distance, you exert a larger force over a short distance. This statement is the definition of work. Work is defined mathematically as

$$\text{Work} = (\text{Force}) \times (\text{distance})$$

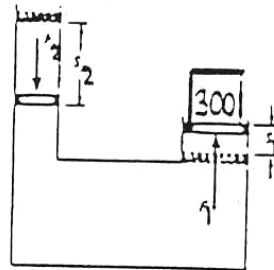
For an ideal system, the work put in equals the work coming out. Friction causes inefficiency and results in the work-out or W_{out} to be less than W_{in} .

$$\text{Efficiency} = W_{\text{out}} / W_{\text{in}}$$

This fraction is never greater than 1. Hydraulics use a liquid or a gas to transmit forces from one surface to another. A force acting on a surface is called pressure and is calculated by

$$\text{Pressure} = \text{Force} / \text{Area}$$

In hydraulic systems, the pressure is the same throughout the fluid. Therefore, you can control the forces by changing the size of the surface area. The following example will show you how you can lift a weight with little effort by using hydraulics.



The two pistons do the same amount of work. The smaller force (f.) moves through a larger distance than the larger force (F.).

A 300 pound weight rests on a hydraulic surface with an area of 376 square inches (2 square feet). What force is needed to act upon the smaller surface having an area of 36 square inches (six by six)? Also, how far will you have to push the small surface to make the weight rise 1 inch?

First you need to calculate the pressure in the fluid, which is $P = 300\text{lb}/376$ square inches.

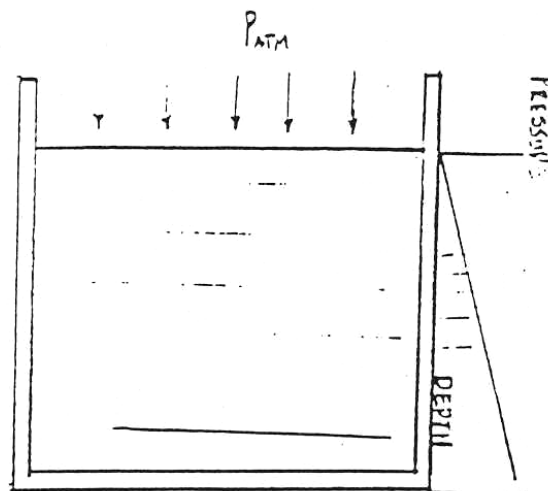
$$P = 0.80 \text{ lb/in}^2$$

This pressure is the same throughout the system. To find the force needed on the other surface, you need to rearrange the pressure equation and solve for the force. $F = P \times A$. So the force is

$$(0.80 \text{ lb/in}^2) \times 36\text{in}^2 = 28.8 \text{ lbs}$$

HYDROSTATIC PRESSURE

Pressure in liquids that are not moving is called hydrostatic pressure, and is caused by gravity. The pressure increases as you get deeper. In fact, as you go twice as deep, the hydrostatic pressure will be twice as much. To calculate the total pressure at any depth in a fluid, you add the hydrostatic pressure to the atmospheric pressure. Atmospheric pressure is caused by the weight of air between the earth's surface and space.

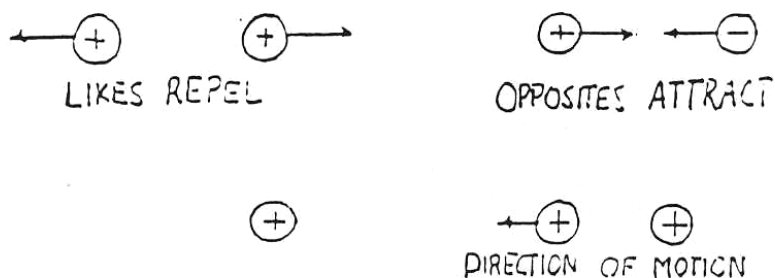


HEAT TRANSFER

Energy travels from objects of different temperature in the form of heat. conduction, convection, and radiation are the three ways that heat transfers. Conduction happens in solids, or in stationary fluids. Convection occurs in liquids and gasses by circulating currents caused by a difference in density. All objects radiate heat; most of which is infrared radiation that is not visible. Conductive heat transfer depends on the temperature difference. The temperatures involved are not important. Nor does it matter whether one is cold rather than hot. The heat will flow from the hot object to the cold object. The rate of heat transfer will be greater for a larger temperature difference.

ELECTRICAL FORCES

Electrical forces are caused by electrical charges which may be positive or negative. Opposite charges attract, and like charges repel. Electrical forces decrease as the distance between charged particles increases. Particles that are close will exert greater forces on each other than particles which are far apart.



ELECTRICAL CIRCUITS AND TERMINOLOGY

Circuit Elements



Resistors - dissipate energy through heat.



Capacitors - store electrical energy between two parallel plates.



Inductors - Store magnetic energy .

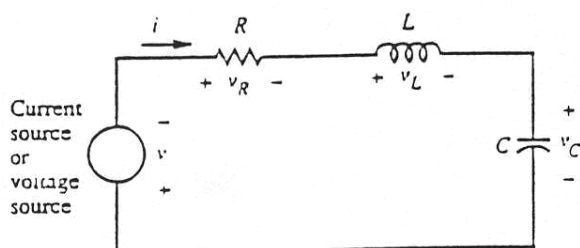


Diodes - restrict current to only one direction. A semiconductor used as a rectifier. Rectifiers convert AC to DC.

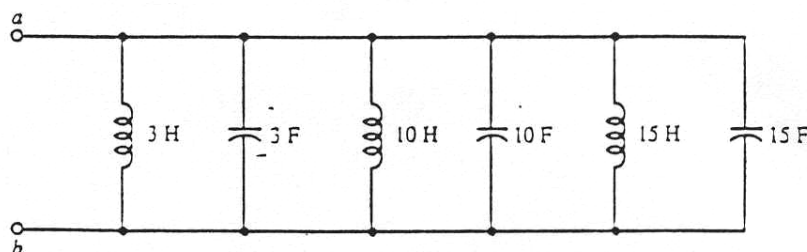
Transformers - used to convert electricity from one voltage to another

Circuits

There are two kinds of circuits that you are responsible for: parallel circuits and series circuits. Combinations of these are called parallel-series circuits. Parallel circuits are identified by seeing several circuit elements, (resistors, lights, etc.) running between parallel to each other between the positive and negative sides of the power source. In series circuits, all of the circuit-elements are in a row along a single wire similar to a set of Christmas tree lights



SERIES



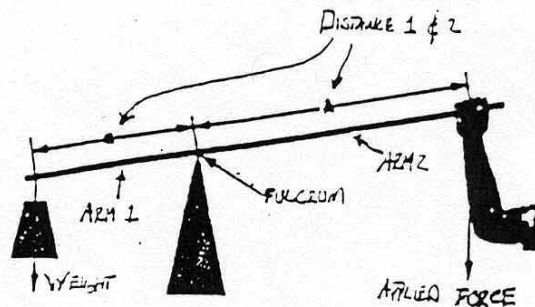
PARALLEL

You've probably noticed that when one light blows out, the rest of the lights don't work either. That's because the circuit has been broken, and no electricity can flow to the other lights. In a parallel circuit, you can see that electricity will still flow to the other lights if the circuit is broken by one of the lights. The electrical outlets in your house are wired in parallel.

You should know that for series circuits, the current is constant through all of the electrical elements. Current in a wire is like water through a pipe. Large values of current implies that a lot of energy is present. In parallel circuits, the current gets divided between two or more elements. Like a pipe that suddenly turns into two pipes, the larger portion of current goes where it's most needed. You should also know that the voltage across all of the elements in a parallel circuit is the same. As you follow the path of the current from the positive node away from the battery and through an element, the voltage will be the same as the battery until the current goes through the element. After crossing a resistor, there will be a voltage drop. This voltage drop is determined by the resistance and the current. Multiplying the two, $V = I \times R$ (this relation is called Ohm's law), will give you the voltage drop. In a series circuit, the voltage will continue to drop as it passes through elements until it has finally dropped to zero.

LEVERAGE PROBLEMS

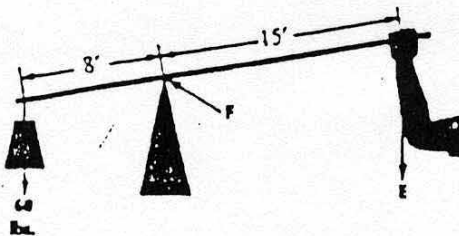
You can expect to see two types of leverage problems. The first has two lever-arms, and the second has one lever-arm. The theory behind leverage is that the longer the lever, the more torque you produce. Torque is the product of force and distance. Force is usually the weight of the object measured in lbs or newtons. Distance is measured between the point where the force is applied, and the point about which it is rotating (fulcrum). You will see problems like this again in ground school. Wings, the tail, passengers, and the weight of the aircraft all add torques (or moments) to the airplane that affect the way the plane flies. Notice that doubling the length of the lever-arm doubles the amount of torque that you apply. Someone once said that with a long enough lever, you can move the world!



Example:

The torque created by the hand must equal the torque produced by the weight before it can be lifted.

$$\text{Torque} = \text{Force} \cdot \text{Distance}$$



Left side: Force = 60 lbs
Distance to fulcrum = 8 ft

Right side: Force = ?
Distance = 15 ft

Torque on left arm = torque on right arm.

$$(60)(8) = (F)(15)$$

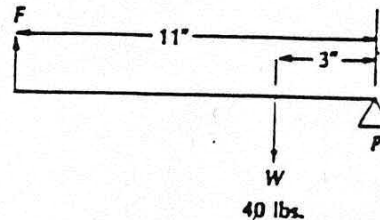
$$F = 32 \text{ lbs}$$

The mechanical advantage of a lever is calculated by dividing the arm-length that you are applying a force, by the arm-length of the resisting weight.

$$MA = \text{Effort Arm} / \text{Resisting Arm}$$

In this example, $MA = 15/8 = 1.88$.

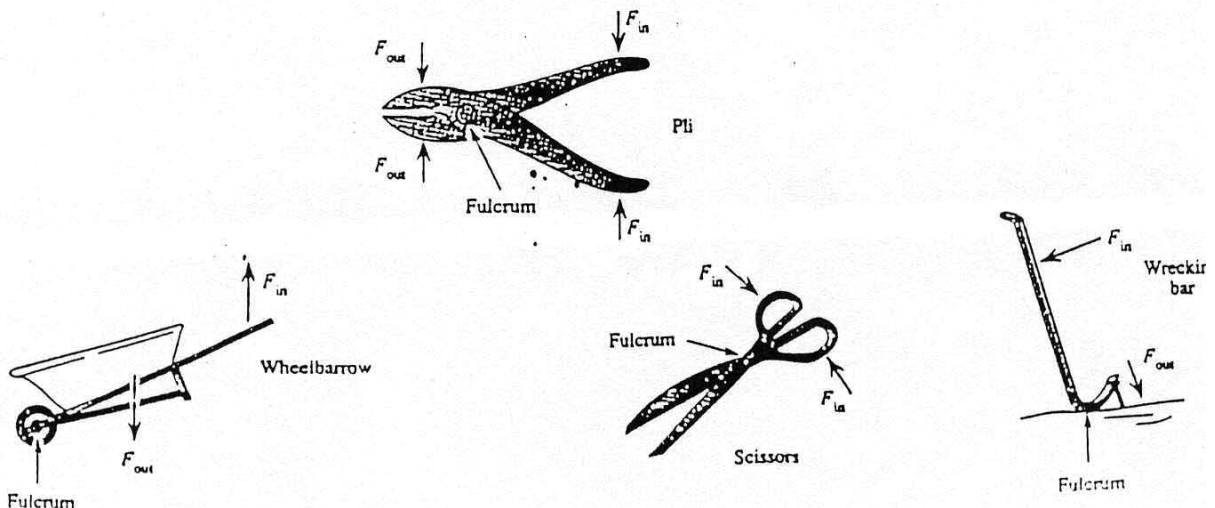
You may see problems where weights and forces are acting on a single lever arm. It is possible that you will see a combination of both. In these cases you have to realize that torque acts in two directions: clockwise and counterclockwise. Look at the problem and determine which forces will turn the arm in a clockwise direction. Add these up. Then do the same for the counterclockwise direction. Set these two summations equal to each other and solve for the unknown force or distance.



The force F will turn the bar clockwise. It acts over a distance of 11" from the fulcrum. Thus, the clockwise torque is $(11)(F)$. The counterclockwise torque is 120 inch-lbs. So,

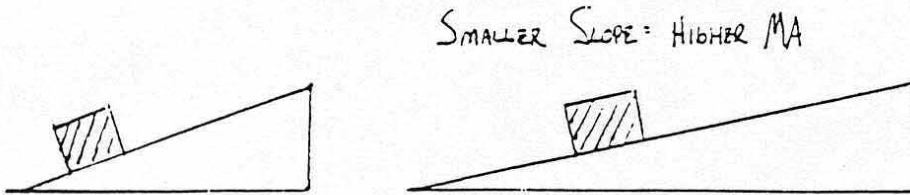
$$\begin{aligned} 11F &= 120 \\ F &= 10.9 \\ F &\approx 11 \text{ lbs} \end{aligned}$$

A pair of pliers, a wheelbarrow, scissors, and a wrecking bar have something in common. They all are levers. A lever uses two forces around a point of rotation, called a fulcrum, to generate a mechanical advantage

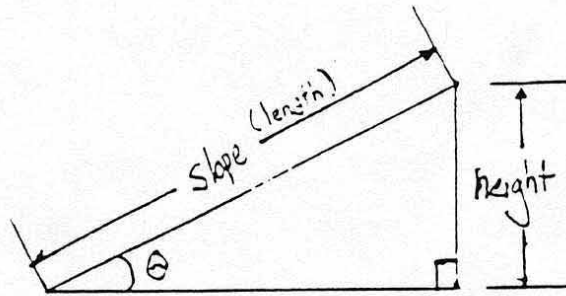


INCLINE SLOPE PROBLEMS

These problems involve the force needed to push a weight up an inclined slope. The mechanical use of this is that you need less force to push something up a hill, than to lift it directly off the ground. So a gradual slope will offer a higher mechanical advantage than a steep slope.



Pushing a weight up an incline requires only a fraction of the force needed to lift the weight directly. This fraction is found by calculating the ratio of the slope-length divided by the height. In mathematical terms, MA is the opposite leg divided by the hypotenuse of a right triangle ($\sin \theta$).



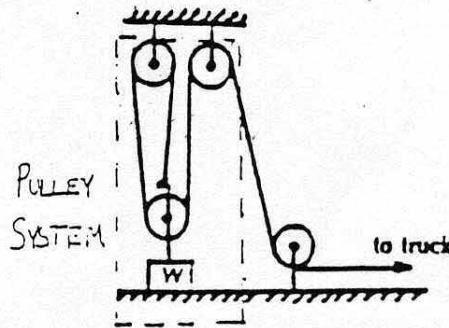
For a height of 5 and a slope-length of 10, the $MA = 2$. For a 100 lb object, this means that only 50 lbs is needed to push it up the incline to reach that height.

PULLEY SYSTEMS

1. Determine what pulleys and ropes are needed to calculate the mechanical advantage.
2. Calculate the mechanical advantage.
3. Solve what the problem asks for.

Determining what pulleys and ropes are relevant.

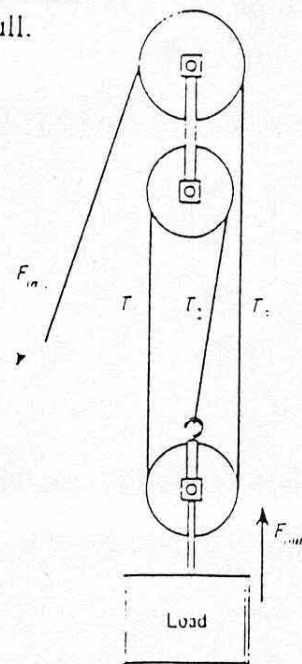
In a given problem, some of the pulleys may not be part of the actual pulley system. These pulleys guide the rope so that the system works more efficiently, but they do not improve the mechanical advantage. To determine which ropes are part of the pulley system, locate the first pulley which is free to move. Then trace back to the previous pulley which is stationary. This is the beginning of your system. The rope that connects these two pulleys is the first rope. Then count the number of ropes contained within the arrangement of closely spaced pulleys. The last rope will be fixed to one of the pulleys, or a wall.



The mechanical advantage equals the number of ropes within the system. If the MA is 4, then pulling with a hundred lbs will allow you to lift 400 lbs. Also (with MA = 4), the weight will raise 1 foot for every 4 feet that you pull.

$$T_1 = T_2 = T_3 = F_{in}$$

Tension is defined as the force that the rope sustains internally. The force that is needed to move the weight is equal to the tension in the rope where someone is pulling it. When several ropes are in contact with the weight, they all contribute equally (if they are all aligned straight up as they will be in your problems.) For instance in the figure to the right, three ropes are holding the weight up. Therefore they each contribute 1/3 of the force needed to hold the weight. This force is the tension, and it is 1/3 the amount of the weight.



The load is supported by three strands of rope. If there were no friction, F_{in} would equal one-third of the load.

- That's only 10% of the weight! You can see now how small engines can develop very large forces. The price for this increase in force is that you have to move the small surface a longer distance. If the larger surface moves 1 inch, you can calculate the distance traveled by the smaller surface by

$$(\text{Area-1}) \times (\text{Displacement-1}) = (\text{Area-2}) \times (\text{Displacement-2})$$

This is another way of saying that the volume of fluid displaced by one piston equals the volume of fluid displaced by the other. After substituting values from the example.

$$(376 \text{ in}^2) \times (1 \text{ in}) = (36 \text{ in}^2) \times (\text{Displacement-2})$$

$$\text{Displacement-2} = (376/36) \text{ inches} = \mathbf{10.4 \text{ inches}}$$

The number 10.4 is the ratio of the two areas.

$\frac{\text{Area-2}}{\text{Area-1}} = \frac{\text{Displacement-1}}{\text{Displacement-2}}$

When we calculated the forces, we were unintentionally using the area ratio. Forces and displacements are calculated from this ratio.

$\frac{\text{Area-2}}{\text{Area-1}} = \frac{\text{Force-2}}{\text{Force-1}}$
