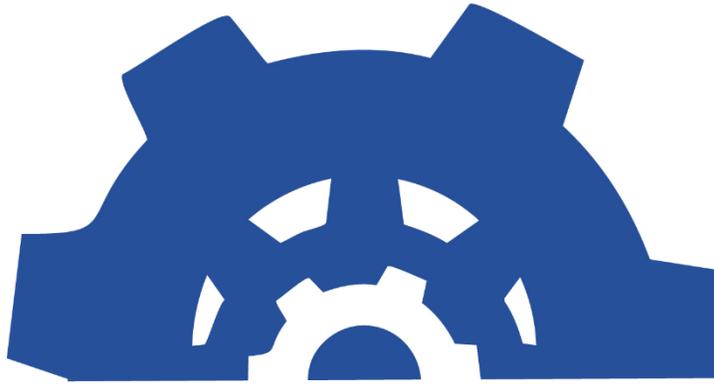# 2026 TECHNICAL SCHOLAR

APTITUDE TEST STUDY GUIDE

TECHNICAL SCHOLAR

Name: _____

Date: _____

Table of Contents

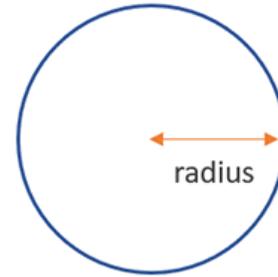# Spatial Geometry

Before we start: A question that will always be on the test no matter what is "What is a grease fitting referred to as?"   Answer: **Zerk fitting**

Area of a Circle: πr^2

- The area of a circle is π multiplied by the radius squared.
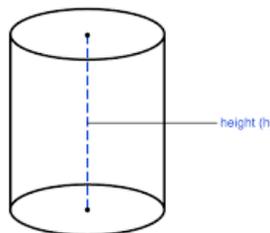
- $\pi \approx 3.14159$

radius

Cylinders

When understanding geometry that will be on the test, visualization is critical for better understanding and foregoing memorization. Here is an example of how it can be used to derive the formula for a cylinder's volume from a basic understanding of dimensions.
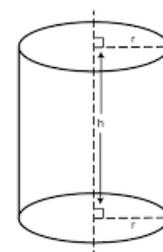
- Height of a Cylinder

Height of a Cylinder
height (h)

Volume of a Right Circular Cylinder
Formula:
Volume (V) = $\pi r^2 h$
Here,
$\pi = \frac{22}{7} = 3.141$,
r = radius, h = height

- The Volume of a Cylinder

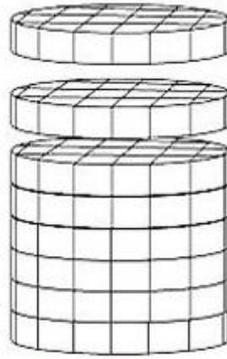   - When looking at the shape it's important to realize that the volume of a cylinder is simply derived from the area of its base stacked on top of itself (h) times. A key separation between the area of the base and the volume is the units being used. The base is expressed in units squared and the volume is always expressed in units cubed (i.e. mm^3). A visualization of this is illustrated in the following images.
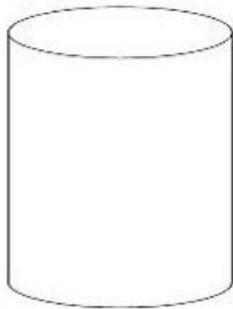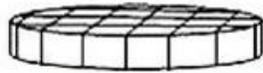
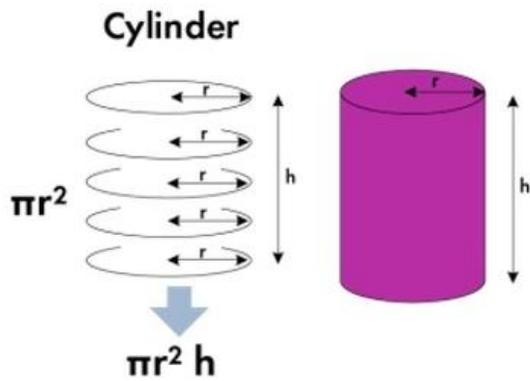Cylinder | How many cubic units in one layer? | How many layers fill the cylinder?

- The formula can also be practically observed like so…

Cylinder

πr^2

$\pi r^2 h$

- Now that you understand this, you can see how the formula for the volume of a cube and other shapes are derived.

Volume of a Cube

- The volume of a cube is Length * Width * Height (l*w*h)
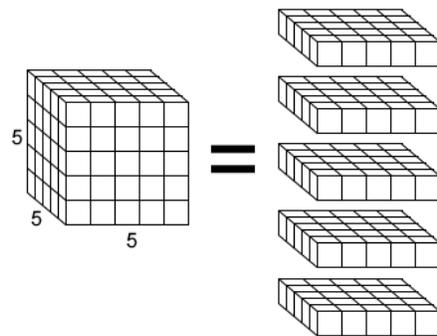
Mechanical Advantage and Simple Machines

In general, simple machines can be defined as the simplest mechanisms that use mechanical advantage (also called leverage) to multiply force. The six classical simple machines are the **Lever**, **Wheel and Axle**, **Pulley**, **Inclined Plane**, **Wedge**, and **Screw**.

These Simple Machines can be used to multiply output force from a tradeoff with distance. The multiplication factor or ratio of this tradeoff between force and distance is often referred to as Mechanical Advantage (MA) or Independent Mechanical Advantage (IMA) though these are the same thing. It is very useful when evaluating mechanics to know all the formulas for the six classical simple machines but as far as I know only Levers, Inclined Planes, and Pulleys were the only simple machines I remember from the test.

For Inclined Planes: IMA = (Length of incline plane) / (Height of incline)

- So, in other words, the tradeoff between distance and force ratio is the ratio between the length of the incline plane and the height of the incline. This ratio corresponds to the effort force required to move the object (the square along the distance of the incline) to the weight of the object. So, if the weight of the object is 50lbs and the length of the incline is 10ft and the height is 1ft what is the force required to move the object to the top of the incline plane. The IMA=10 so 50lbs/10 = 5lbs of force is required to move the object.


Incline $\qquad IMA = \dfrac{L}{h}$
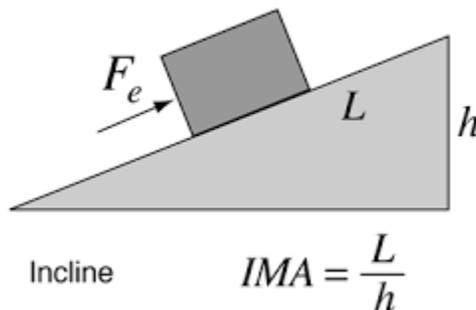
For Levers: IMA = (Length of the Effort Arm)/(Length of the Weighted or Resistance Arm)

- The pivot axis for a lever is referred to as the **fulcrum**. The fulcrum plays no part in the equation for the mechanical advantage other than where it is. The fulcrum is necessary to consider as there are 3 different types of levers in mechanics, but it is not critical to know this for the exam. Just know, the IMA is the ratio of the two lengths.

$$IMA = \frac{L_e}{L_r}$$
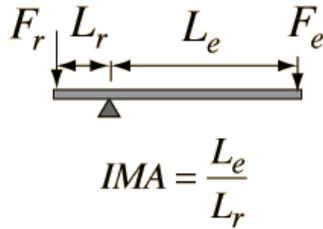
For Pulleys: IMA = (Load Force)/(Effort Force)

- The reason the IMA for a pulley is a little different than other measurements of simple machines is because pulleys can yield different mechanical advantages based on how the pulley and the weight are rigged. Often (but not always) the mechanical advantage of a pulley rig is the number of pulleys being used in the rig.

- The rigging in this situation has an effort force of 50lbs, the resistance force is 150lbs the IMA = 150/50 = 3. The IMA in this situation is 3, which happens to be the same as the number of pulleys.
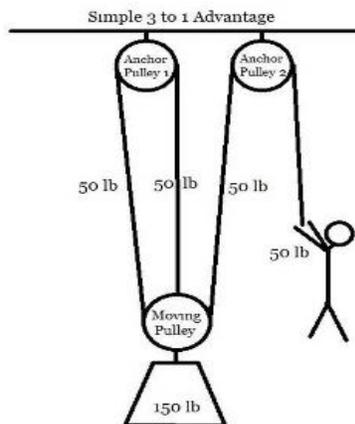
Gear Ratios

A gear ratio is the ratio of teeth on a driven gear to the teeth on a driving gear. A great illustration of this is shown below.
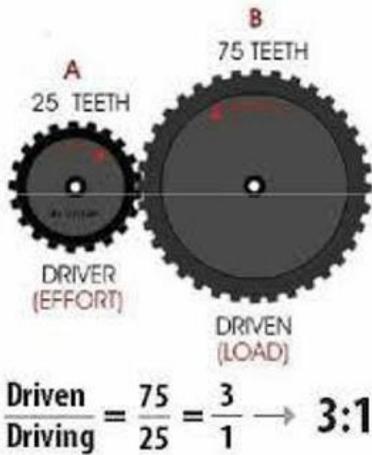

The gear ratio also corresponds with rpm and torque though these vary inversely. For example, let's say the Driving gear has a speed of 30 rpm the rpm difference in the driven gear is going to be the reciprocal of the gear ratio or in this case 1/3rd as much, making the driven gear have a speed of 10rpm. The torque, however, is directly proportional to the gear ratio. If the driver gear has an input torque of 10N-M the Output torque of the Driven gear would be 30N-M in this case because the gear ratio is 3.

Ohmic Values and Ohms Law

Ohm's Law is the relationship between **current**, **voltage**, and **resistance**. The formula that expresses this is V=I*R (Voltage = Current multiplied by Resistance). In an electrical circuit current is inversely proportional to resistance (i.e. as resistance is increased the current in the circuit decreases). The current in the circuit is directly proportional to the voltage of the circuit (i.e. as the current in the circuit increases the voltage also increases proportionally).

There may not be many questions on the test that require going more in depth into finding values for circuits, but you will have to use V=I*R and you will be required to transform the equation to find current and resistance values. Transforming the equation will yield you separate equations such as I= V/R and R= V/I. It is also important to note that the **Power** of a circuit is P=V*I and is expressed in Watts (W).

One question that will be on the test is "How much resistance, in Ohms, is a 1000ft cable, if a 500ft section of the cable is 25 ohms?" The solution to the problem is just 50 ohms as the cable will have twice the resistance as the wire is doubled in length.
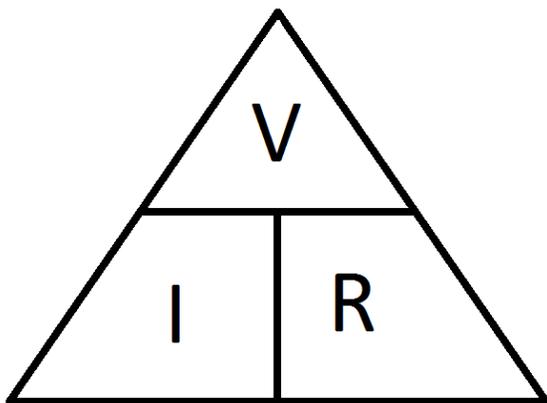
$$I = V/R$$

$$V = IR$$

$$R = V/I$$

Ohmic Values Cont.

The difficult thing about electricity is that it is very abstract in much of the math that surrounds it. It is not physical in regard to touching it or seeing it move but it is rather a transfer of energy. The best analogy for simplistic understanding is using a water pipe to express your circuit. In general terms, charge is water, voltage is the pressure of water, current is the flow of the water. Power is the total amount of water flowing in a given time. Resistance in the circuit can be a narrowing of the pipe that restricts the flow of water.

Other things about electricity that will be in the test are:

- What type of materials allow electricity to flow? Answer: Conductors

- What type of materials prevent electricity from flowing? Answer: Insulators/Dielectrics

- What type of materials are conductors? Answer: Metals

- What type of materials are insulators/dielectrics? Answer: Plastics, Rubbers & Non metallics
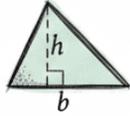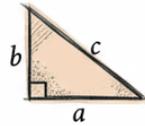
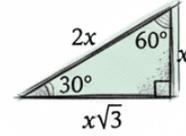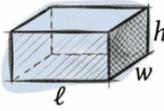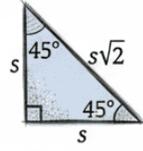# Additional Important Formulas
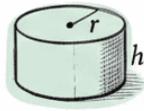
$A = \pi r^2$
$C = 2\pi r$

rectangle

$A = \frac{1}{2}bh$

$c^2 = a^2 + b^2$
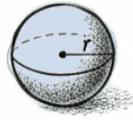
Special Right Triangles
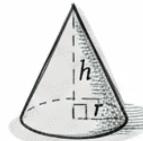
$V = \ell wh$

$V = \pi r^2 h$

$V = \frac{4}{3}\pi r^3$

$V = \frac{1}{3}\pi r^2 h$

$V = \frac{1}{3}\ell wh$

The number of degrees of arc in a circle is 360.
The number of radians of arc in a circle is 2π.
The sum of the measures in degrees of the angles of a triangle is 180.

SIX CLASSICAL SIMPLE MACHINES FORMULAS AND CONFIGURATIONS
Only Lever, Incline Plane, and Pulleys were seen on the test

Lever $\quad IMA = \dfrac{L_e}{L_r}$

Incline $\quad IMA = \dfrac{L}{h}$

Wheel and axle $\quad IMA = \dfrac{R}{r}$

Wedge $\quad IMA = \dfrac{L}{t}$

Pulley $\quad IMA = N$

Screw $\quad IMA = \dfrac{2\pi L}{P}$