

Science Olympiad
Simple Machines
Division B

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Simple Machine Rules

Team of 2

No Eye Protection Required

Device must be impounded

Part 1 (Written Test)

- 50% of score
- SI Units
- Simple Machine Concepts
- Simple Machine Calculations
- Simple Machine History

Part 2 (Device Testing)

- One known and one unknown mass (50-1200g each)
- 5:1 (Reg)

Simple Machine Rules

Types of machines included

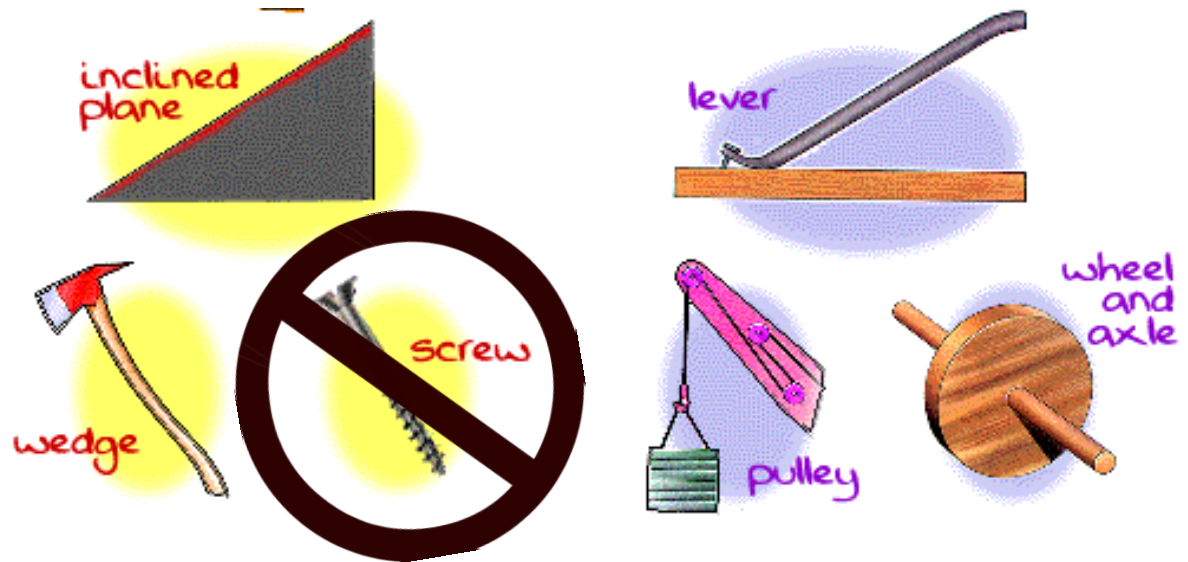
- Levers (all three classes)
- Inclined Wedge
- Wedge
- Pulley (up to two double pulleys)
- Wheel and Axle

Prohibited topics

- Compound machines
- Dynamic Calculations
- Material Strengths
- Potential/Kinetic Energy
- Coefficient of Friction
- Screw Simple Machines
- Angle of Repose

Simple machine Basics

- Lever
- Inclined Plane
- Wheel and Axle
- Wedge
- Pulley



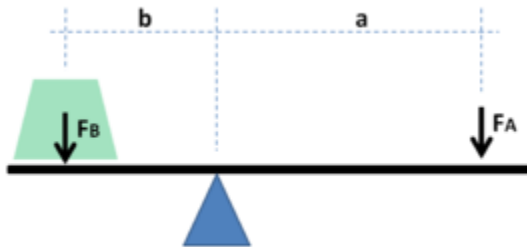
- Screw, not included in Simple Machines (B)

Scoring

- Exam Score (ES) is worth 50 points (or 50% of total)
- Device Measurement counts for 50% of total, with Actual Mass (AM) and Calculated Mass (CM)
 - Time Score (TS) = $((240 - \text{time}) / 240) * 20$ points
 - Mass Score (MS) = $(1 - (\text{abs}(AM - CV) / AM)) * 30$ points
 - Teams with no device or mass estimate or that do not make an honest attempt = 0 points for Device Measurement
- Final Score (FS) = ES + MS + TS (maximum of 100 points)
- Tie Breakers
 1. Best MS score
 2. Best ES score
 3. Best TS score
 4. Specific Test Questions

Mechanical Advantage

- A simple machine has an applied force (or effort) that works against a load force.
 - If there are no friction losses, the work done on the load is equal to the work done by the applied force.
 - This allows an increase in the output force at the cost of a proportional decrease in the distance moved by the load.
 - The ratio of the output force to the input force is the η of the machine.



$$MA = \frac{F_{out}}{F_{in}} + \frac{V_{in}}{V_{out}}$$

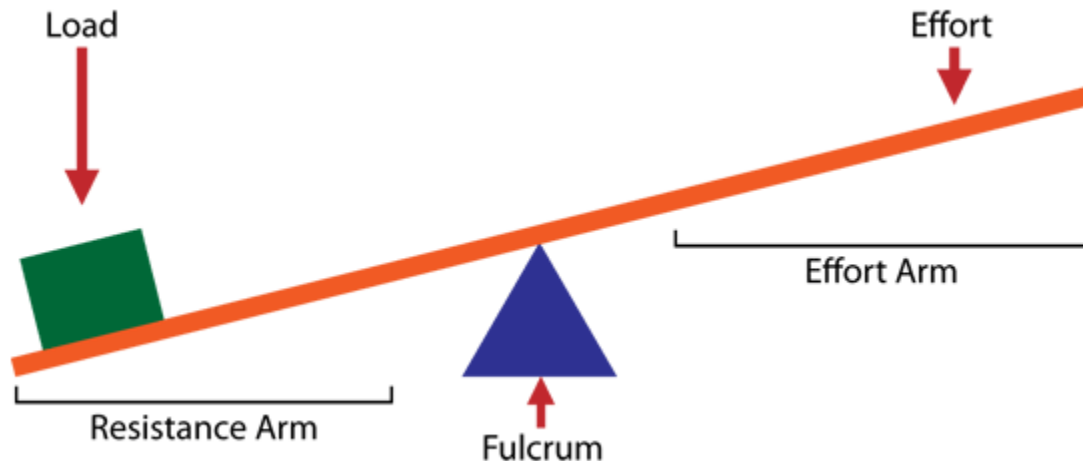
Efficiency

- Machines lose energy through friction, deformation and wear, which is dissipated as heat.
- This means the power out of the machine is less than power in.
- The ratio of power out to power in is the efficiency η of the machine, and is a measure of the energy losses.

$$\eta = \frac{P_{out}}{P_{in}} \quad MA = \frac{F_{out}}{F_{in}} + \eta \frac{V_{in}}{V_{out}}$$

What is a lever?

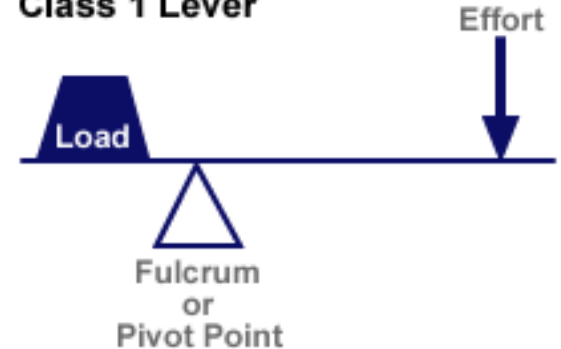
- A lever is a machine consisting of a beam or rigid rod pivoted at a fixed hinge, or fulcrum
 - A lever amplifies an input force to provide a greater output force, which is said to provide leverage.
 - The ratio of the output force to the input force is the



Classes of Levers

- Class 1: Fulcrum in the middle: the effort is applied on one side of the fulcrum and the resistance on the other side
 - A crowbar or a pair of scissors.
- Class 2: Resistance in the middle: the effort is applied on one side of the resistance and the fulcrum is located on the other side.
 - A wheelbarrow, a nutcracker, a bottle opener or the brake pedal of a car.
Mechanical advantage is greater than 1.
- Class 3: Effort in the middle: the resistance is on one side of the effort and the fulcrum is located on the other side
 - A pair of tweezers or the human mandible.
Mechanical advantage is less than 1.

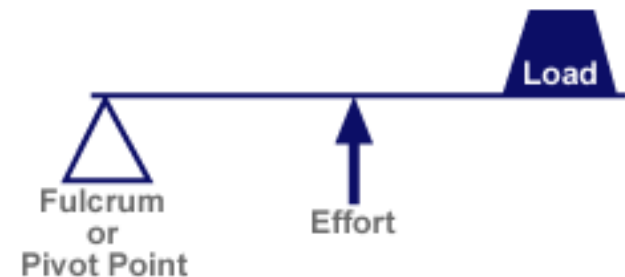
Class 1 Lever



Class 2 Lever

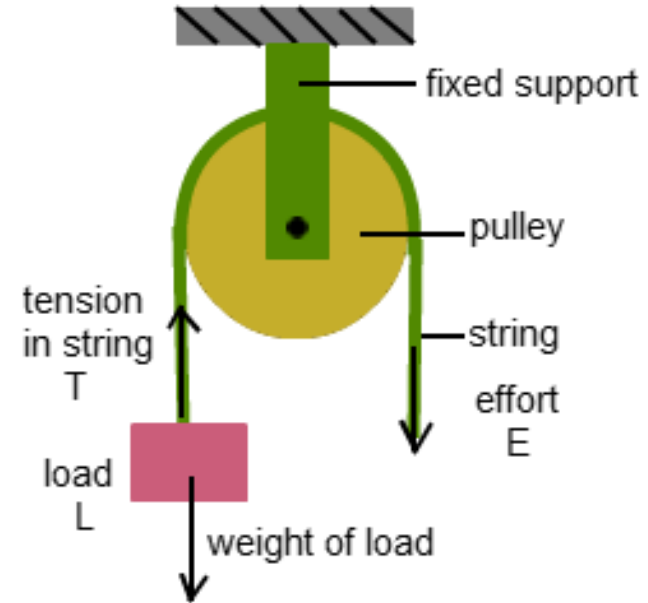


Class 3 Lever



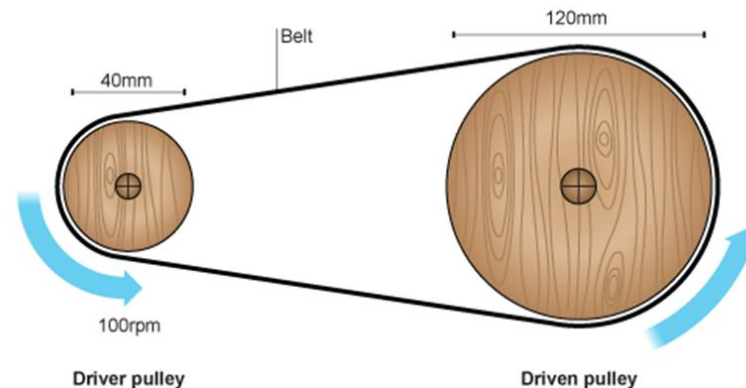
What is a pulley?

- A pulley is a wheel on an axle that is designed to support movement of a cable or belt along its circumference.
 - Pulleys are used in a variety of ways to lift loads, apply forces, and to transmit power.
 - Also called a block, sheave, or drum and may have a groove between two flanges around its circumference.
 - The drive element of a pulley system can be a rope, cable, belt, or chain that runs over the pulley inside the groove.



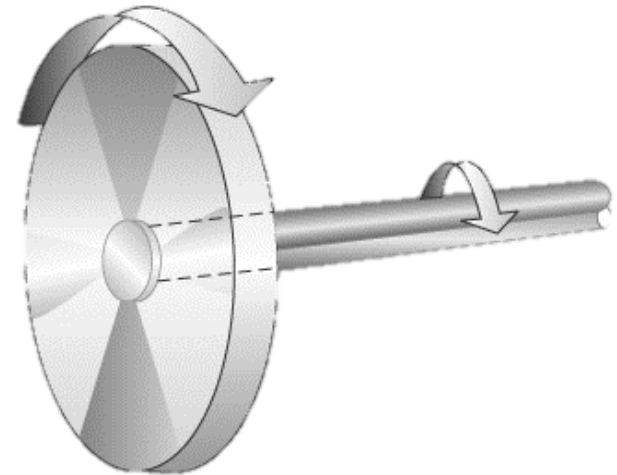
Pulleys linked by a circular chain or belt

- Below is a pulley and belt system, which operates like a Wheel and Axle, but is classified a pulley system
 - Pulleys have different axles
 - Motion is circular/angular not linear
 - The IMA is dependent upon the ratio of the wheels/pulleys versus the number of lines connecting
 - One wheel/pulley is the driver and one is the driven



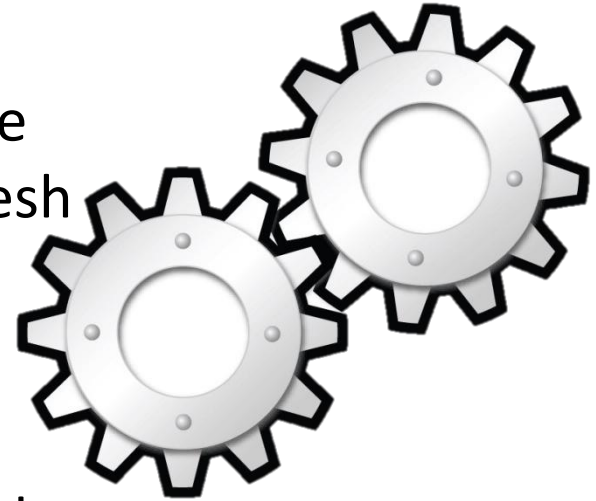
What is a Wheel and Axle

- Wheel and Axle is a simple machine that is generally considered to be a wheel attached to an axle so that these two parts rotate together in which a force is transferred from one to the other.
 - The IMA is caused by the difference in radius between the wheel and axle
 - Either the Wheel or Axle may be the driving force



Gears are also a Wheel and Axle type of machine

- A gear or cogwheel is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part in order to transmit torque
 - Usually the teeth on the one gear of identical shape, and often also with that shape (or just width) on the other gear.
 - Two or more gears working in tandem are called a transmission and can produce a mechanical advantage through a gear ratio and thus may be considered a simple machine.



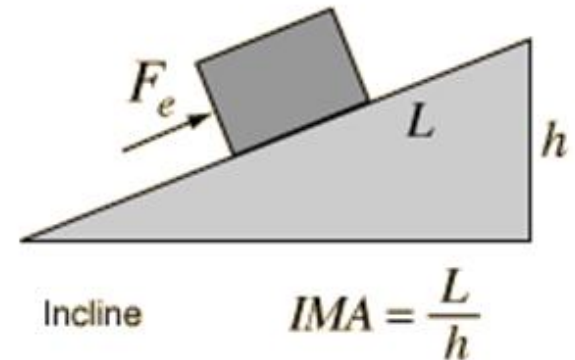
What is a Wedge?

- A wedge is a triangular shaped tool, a compound and portable inclined plane, and one of the six classical simple machines.
 - It can be used to separate two objects or portions of an object, lift up an object, or hold an object in place.
 - It functions by converting a force applied to its blunt end into forces perpendicular (normal) to its inclined surfaces.



What is an Inclined Plane?

- An inclined plane is a flat supporting surface tilted at an angle, with one end higher than the other, used as an aid for raising or lowering a load
 - Can include friction (static only) for Simple Machines (B) or be frictionless.



Suggested References

- **Websites:**
 - Soinc.org Simple Machines/ Complex Machines Event pages
 - Scioly.org student forums / wiki / test exchange
 - Wikipedia (Simple Machines, Levers, Pulleys, etc.)
 - <http://www.khanacademy.org/#Physics>
- [Khan Academy Tutorial on Mechanical Advantage](#)
- [Museum of Science and Industry Simple Machines online game](#)
- [SEDL Simple Machines Online Textbook](#)
- [Department of Navy - Basic Machines Textbook](#)

