Science Olympiad
Simple Machines
Division B

Supervisor: Jacqueline Hencsie
Email: jacqui.hencsie@gmail.com
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
Simples 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-time)/240*20 points
  – Mass Score (MS)=(1-(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 mechanical advantage of the machine.

\[
\text{MA} = \frac{F_{\text{out}}}{F_{\text{in}}} + \frac{V_{\text{in}}}{V_{\text{out}}}
\]
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 $\eta$ of the machine, and is a measure of the energy losses.

\[
\eta = \frac{P_{out}}{P_{in}} \quad \text{MA}= \frac{F_{out}}{F_{in}} + \eta \frac{V_{in}}{V_{out}}
\]
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 ideal mechanical advantage of the lever.
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.
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](http://www.khanacademy.org/#Physics)

- [Khan Academy Tutorial on Mechanical Advantage](http://www.khanacademy.org)
- [Museum of Science and Industry Simple Machines online game](http://www.museumofscience.org)
- [SEDL Simple Machines Online Textbook](http://www.sedl.org)
- [Department of Navy - Basic Machines Textbook](http://www.dona.navy.mil)

![Suggested References Logos]