Simple Machines

Simple Machines

- Simple machines are tools that make work easier by decreasing the input force while increasing the input distance
- Simple machines do NOT reduce the amount of work you do
  - The same amount of work is done whether or not a simple machine is used
- Simple machines can be combined to create complex (compound) machines

Simple Machines

- Types of Simple Machines
  - Inclined Plane: a slanted surface with one end higher than the other
  - Wedge: two inclined planes with a pointed end used to split objects
  - Screw: an inclined plane wound around itself with a wedge tip

Simple Machines

- Types of Simple Machines
  - Lever: flat surface that rests on a turning point
    - The turning point is called the fulcrum
    - Classes of Levers
      - 1st Class: fulcrum is in the between of the effort & resistance forces
      - 2nd Class: resistance force is between the effort force and the fulcrum
      - 3rd Class: the effort force is between the resistance force and the fulcrum

Lever Classes

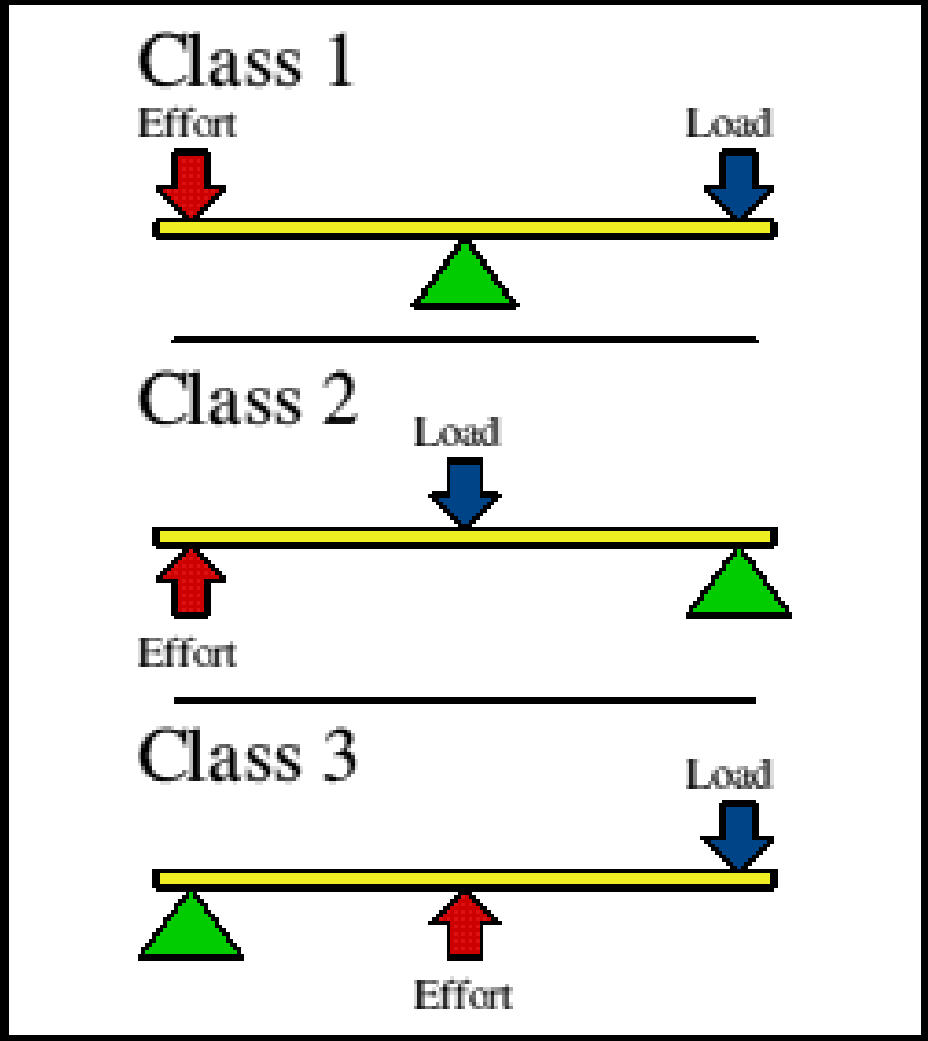


Image from https://www.sites.google.com/site/rubegoldberg5236/levers

Simple Machines

- Types of Simple Machines
  - Wheel & Axle: circular lever wrapped around a central support
  - Pulley: variation of a wheel & axle with a cord or rope taking the place of the axle
    - Types of Pulleys
      - Can be fixed or movable, simple or compound

Mechanical Advantage and Efficiency

Simple Machines

- Terms
  - Effort Force (aka input force)
    - force applied to the machine
  - Effort Distance (aka input distance)
    - distance the effort force is applied over
  - Resistance Force (aka output force)
    - force the machine is acting against or trying to move
  - Resistance Distance (aka output distance)
    - distance the machine is trying to move the object over

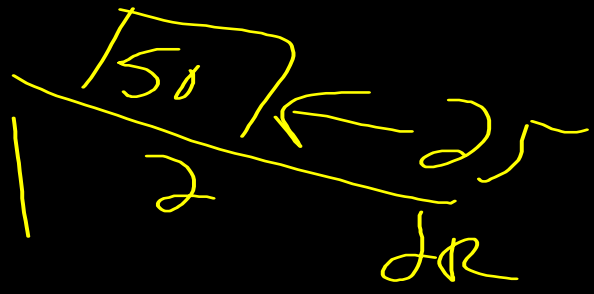
Simple Machines

- Inclined Plane
  - Effort distance = length of ramp
  - Resistance distance = height of ramp
- Lever
  - Effort distance = distance from fulcrum to your force
  - Resistance distance = distance from fulcrum to mass you are moving
- Pulley
  - MA determined by number of supporting ropes

Simple Machines

- Mechanical Advantage
  - Ideal Mechanical Advantage is the amount of effort that could be saved if the machine was 100% efficient
    - $IMA = d_E / d_R$
  - Actual Mechanical Advantage is the amount of effort that is saved by a machine
    - $AMA = F_R / F_E$
- Efficiency
  - Ratio of work applied to work achieved
  - $Eff. = ((W_O) / (W_I)) * 100$
  - $Eff. = ((AMA) / (IMA)) * 100$

Example



- A 50N box is pushed 2m up a ramp that is 0.5m tall using a force of 25N.
  1. What is the IMA of the ramp?
  2. What is the AMA of the ramp?
  3. What is the work input?
  4. What is the work output?
  5. What is the efficiency of the ramp?

$IMA = \frac{d_E}{d_R} = \frac{2m}{0.5m} = 4$

$AMA = \frac{F_R}{F_E} = \frac{50N}{25N} = 2$

$Eff = \left(\frac{W_O}{W_I}\right)100 = \left(\frac{25J}{50J}\right)100 = 50\%$

$W_I = F_E d_E = (25N)(2m) = 50J$

$W_O = F_R d_R = (50N)(0.5m) = 25J$

Example

- A 180N crate is being raised with 50N of force applied to a 1st class lever. The crate is located 0.4m from the fulcrum and the force is applied 1.6m from the fulcrum.
  1. What is the IMA of the lever?
  2. What is the AMA of the lever?
  3. What is the work input of the lever?
  4. What is the work output of the lever?
  5. What is the efficiency of the lever?

$IMA = \frac{1.6m}{0.4m} = 4$

$AMA = \frac{180N}{50N} = 3.6$

$W_I = F_E d_E = (50N)(1.6m) = 80J$

$W_O = F_R d_R = (180N)(0.4m) = 72J$

$\%\eta = \left(\frac{W_O}{W_I}\right)100 = \left(\frac{72J}{80J}\right)100 = 90\%$