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MAGIC WITH FORCES

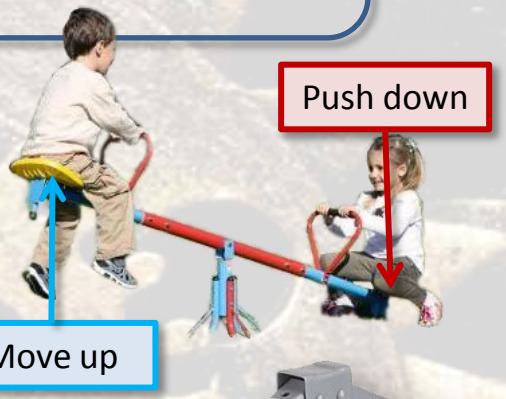
- A little boy and girl are on a see saw. The boy is heavier.
  - We're not surprised to see the girl held in the air.
  - But, can she balance him?
  - Or hold him in the air?

- Consider this. A person of average strength can lift a car by hand to change a tire.
  - All that is needed is a jack.
  - Machines change forces.

MACHINE: A DEFINITION

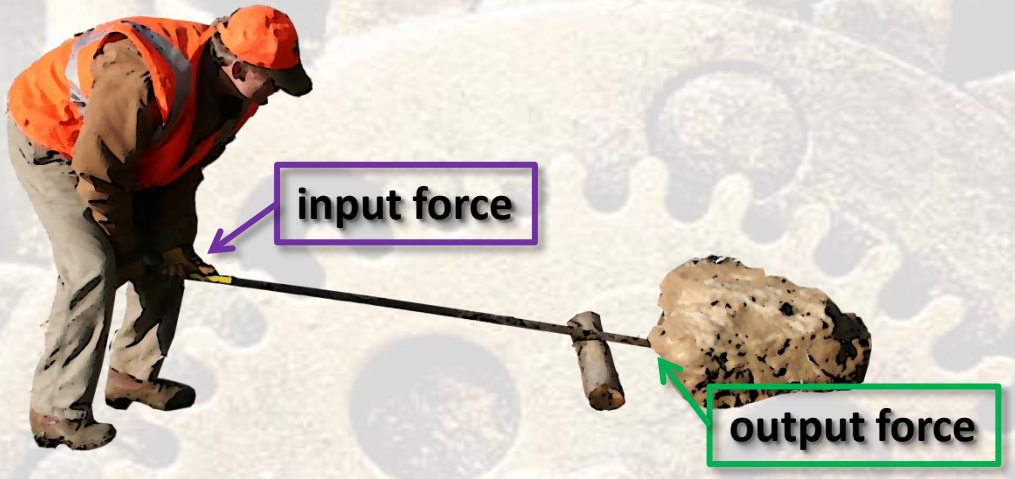
- Machine = device that changes the direction or magnitude and distance through which a force operates.

- Examples
  - A see-saw: push down on one end. The other end moves up.
  - A jack: Use a small force. Move a heavy object.
  - A wrench: Use a small force. Turn a tight nut.

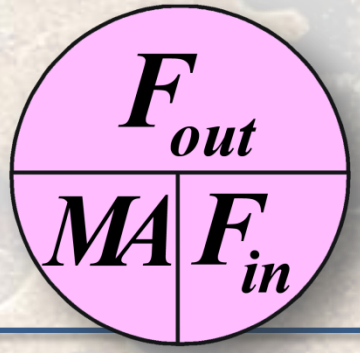


MECHANICAL ADVANTAGE

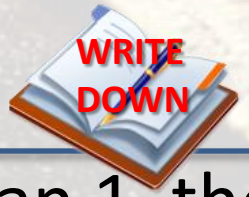
- The applied force to a machine is called the **input force**.
- The resulting force from the machine is called the **output force**.



- The **mechanical advantage** is the ratio of the output force to the input force.
  - $mechanical\ advantage = \frac{output\ force}{input\ force}$
  - $MA = \frac{F_{out}}{F_{in}}$



Mechanical Advantage: Significance



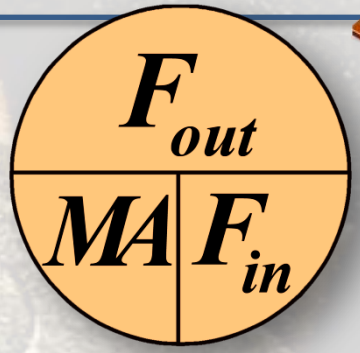
- If the mechanical advantage is greater than 1, the machine makes work easier.
- If it is possible to lift 200 N with an applied force of 100 N, the mechanical advantage is 2.

$$MA = \frac{F_{out}}{F_{in}} = \frac{200\ N}{100\ N} = 2$$

  - Mechanical advantage has no units.

(Note: F_{out} is also the resistance force, F_R; F_{in} is also the effort force, F_E)

SAMPLE PROBLEMS



- What is the mechanical advantage of a machine that can lift 1,000 N with a force of 250 N?

$$MA = \frac{F_{out}}{F_{in}} = \frac{1{,}000\ N}{250\ N} = 4$$

- What is the maximum weight that can be lifted with an applied force of 80 N by a machine with a mechanical advantage of 7?

$$MA = \frac{F_{out}}{F_{in}};\quad 7 = \frac{F_{out}}{80\ N};\quad F_{out} = 560\ N$$

- How much effort is needed to lift a 900 N box using a machine with a mechanical advantage of 6?

$$MA = \frac{F_{out}}{F_{in}};\quad 6 = \frac{900\ N}{F_{in}};\quad F_{in} = 150\ N$$