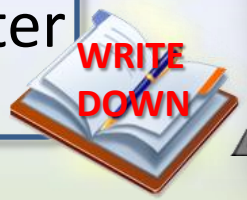
Efficiency

Conservation of Work

- What are the units for work? Joules
- What are the units for energy? Joules
- The units for work and energy are the same.
  - Work ***IS*** energy!
  - Work and energy are both governed by the law of conservation of energy.
  - This means that the work output or energy from a machine cannot be greater than what is put in.



So, How Can a Machine Make Work Easier?

- According to the law of conservation of energy, the work output is equal to the work input ($W_{out} = W_{in}$), certainly never bigger!
- How "easy" or "difficult" the work is depends on the **force** that needs to be exerted.
  - It's easy to pick up a 1 kg mass (about 2 lbs.)
  - It's difficult to pick up a 75 kg mass (about 175 lbs.)

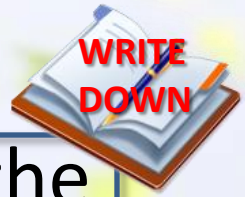
More Making Work Easier

- Keep in mind that work is the product of force and distance ($W = F \times d$)
  - $W_{in} = F_{in} \times d_{in}$
  - $W_{out} = F_{out} \times d_{out}$
- If $W_{out} = W_{in}$ then $F_{in} \times d_{in} = F_{out} \times d_{out}$

- The only way the force you exert (F_{in}) can be smaller than the weight of the mass you are trying to move (F_{out}), is if you exert it through a greater distance ($d_{in} > d_{out}$).

Does Work Input Always Equal Work Output?

- You can't get something for nothing, so work output is **never** greater than work input, . . .
- But you **can** waste effort!
  - If you roll a barrel up a ramp, there is friction.
  - Overcoming friction is not your goal. It is **not** part of the work you're trying to accomplish.
  - It is wasted effort, and wasted work.



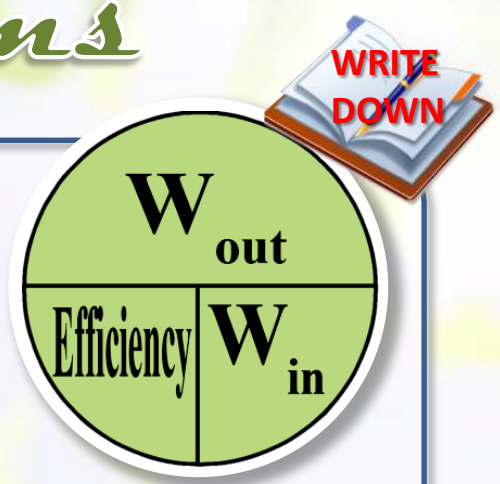
- Work done overcoming friction makes the work input greater than the work output.

Defining Efficiency

- Work output (W_{out}) is all useful work. It is what you are trying to accomplish.
- Work input (W_{in}) is useful work **plus** work done overcoming friction.
- The more work a machine requires in order to overcome friction, the less efficient it is.
- Efficiency is the percentage of useful work out of the total work done.

$$\text{Efficiency} = \frac{W_{out}}{W_{in}} \times 100\ \%$$

Sample Problems



- How efficient is a machine with a work output of 75 J and a work input of 90 J?

$$\text{Efficiency} = \frac{75\ \text{J}}{90\ \text{J}} \times 100\ \% = 83.3\ \%$$

- A machine has an efficiency of 60 percent. How much work was done to accomplish 120 J of work?

NOTE: Express the efficiency as a decimal by dividing by 100.

$$60\ \% = \frac{120\ \text{J}}{W_{in}} \times 100\ \%;\ W_{in} = \frac{120\ \text{J}}{0.60} = 200\ \text{J}$$

- How much useful work was done if a machine with 80 percent efficiency required an input of 500 J?

NOTE: Express the efficiency as a decimal by dividing by 100.

$$80\ \% = \frac{W_{out}}{500\ \text{J}} \times 100\ \%;\ W_{out} = (0.80)(500\ \text{J}) = 400\ \text{J}$$