Bell Ringer

What do you think of when you hear the word **energy**?

(List at least three items in your Bell Ringer)

Bell Ringer 10/25

- What is another term for the ability to do work?

Energy

- Energy: The ability of an object to do work
  - Units: Joules (J)
- Types of energy include:
  - Mechanical: Energy of movement and position
  - Chemical: Energy stored in chemical bonds of molecules

Energy

- Thermal: "Heat energy" stored in materials at a certain temperature
- Nuclear: Energy produced from the splitting of atoms
- Radiant Energy: Energy traveling the form of electromagnetic waves
- Electric Energy: Energy traveling as the flow of charged particles (i.e. electrons)

Work

- Work is done when a task produces a change in energy
- Factors affecting work done:
  - The application of a force
  - The movement of the object by that force over a distance

Bell Ringer

- How much work is required to lift a 2kg object 2m high?

Work

- Therefore:

$$\text{Work} = \text{Force} \times \text{Distance}$$

$$W = Fd$$

- Units: Joule (J)
  - 1 J = 1 N·m
- Note that work requires a distance

Bell Ringer 3/31

- What is another term for the ability to do work?
- You push a stationary wall with a force of 1000N. How much work was done to the wall?

Bell Ringer

Power

- How much work is performed over a period of time
- Therefore:

$$Power = Work / Time$$

$$P = W/t$$

- Units: Watts (W) where 1 W = 1 J/s

Thought Question

- How many horses are in one horsepower?

Power

- Power can also be converted to units of horsepower (hp)
  - Note: 1 hp ≈ 750 W

coffee maker	0.75 hp
blender	1.5 hp
lawn mower	5-6 hp
Corvette	≥400 hp

Bell Ringer

- If Superman, at 90kg, jumps a 40m building in a single bound, how much does Superman perform?
- If this occurs in 3s, what is his power output?

Energy

- The amount of work done by an object does not depend on the path taken
- Work depends only on the object's starting and ending points

- As work is *done* on an object, the object itself gains the opportunity *to do* work

Energy

- For example:
  - A bowstring drawn back on a bow
  - Winding an alarm clock
  - Raising the arm on a pile driver
- All of these objects now have the ability to do work

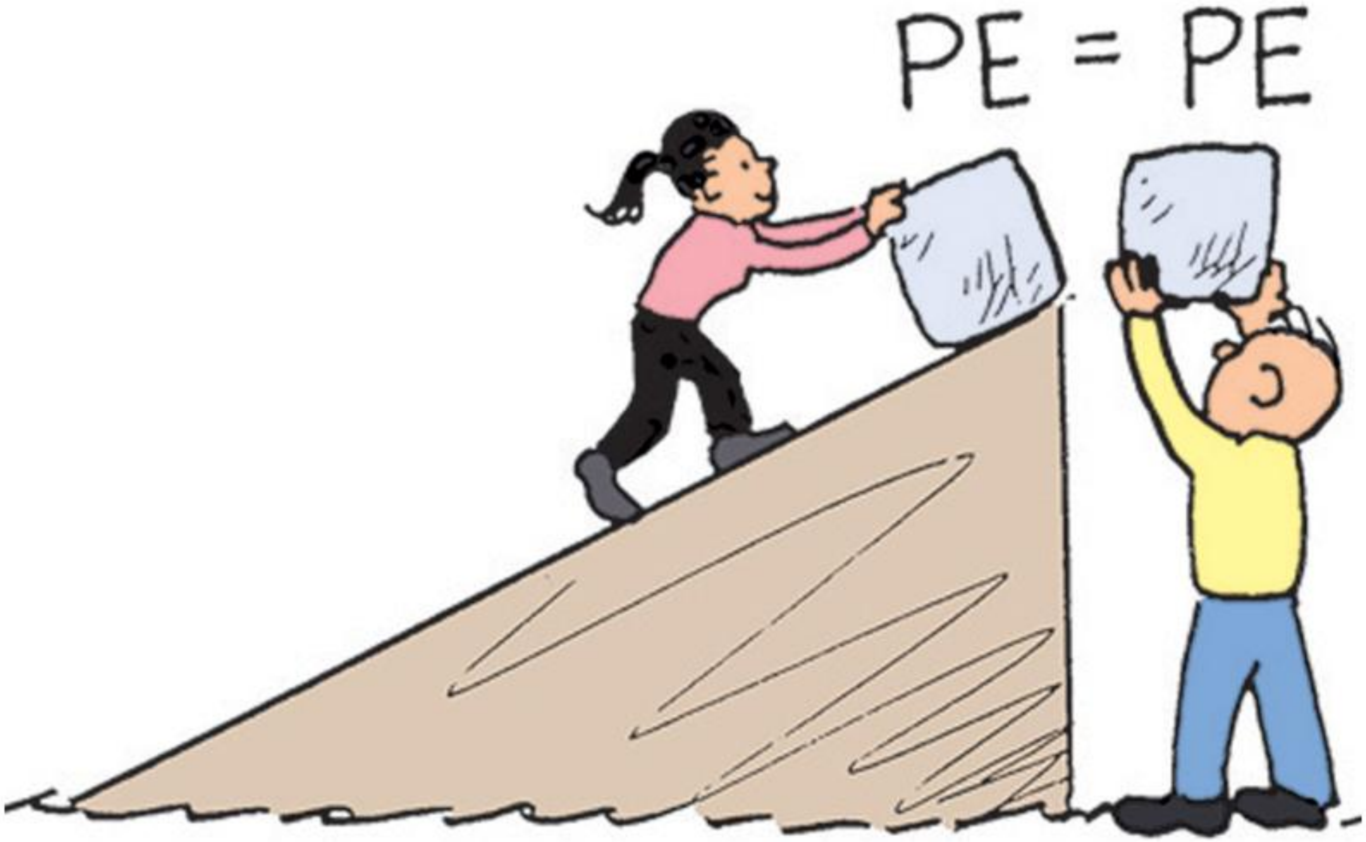
Mechanical Energy

- Mechanical Energy: Energy of movement and position
  - There are two major types of mechanical energy:
    - Potential Energy: Energy of position
    - Kinetic Energy: Energy of motion

Potential Energy

- Gravitational Potential Energy: The potential due to elevated positions
- P.E. = mass x gravity x height
  - P.E. = mgh
- Recall: weight = mass x gravity
  - Therefore: P.E. = weight x height

Potential Energy



Kinetic Energy

- Objects in motion are capable of doing work

$$KE = \frac{1}{2} \cdot mass \cdot velocity^2$$

$$KE = \frac{1}{2}mv^2$$

Kinetic Energy

- Note that the velocity of the object is squared when determining KE
  - If the velocity of the object is doubled, the KE is quadrupled

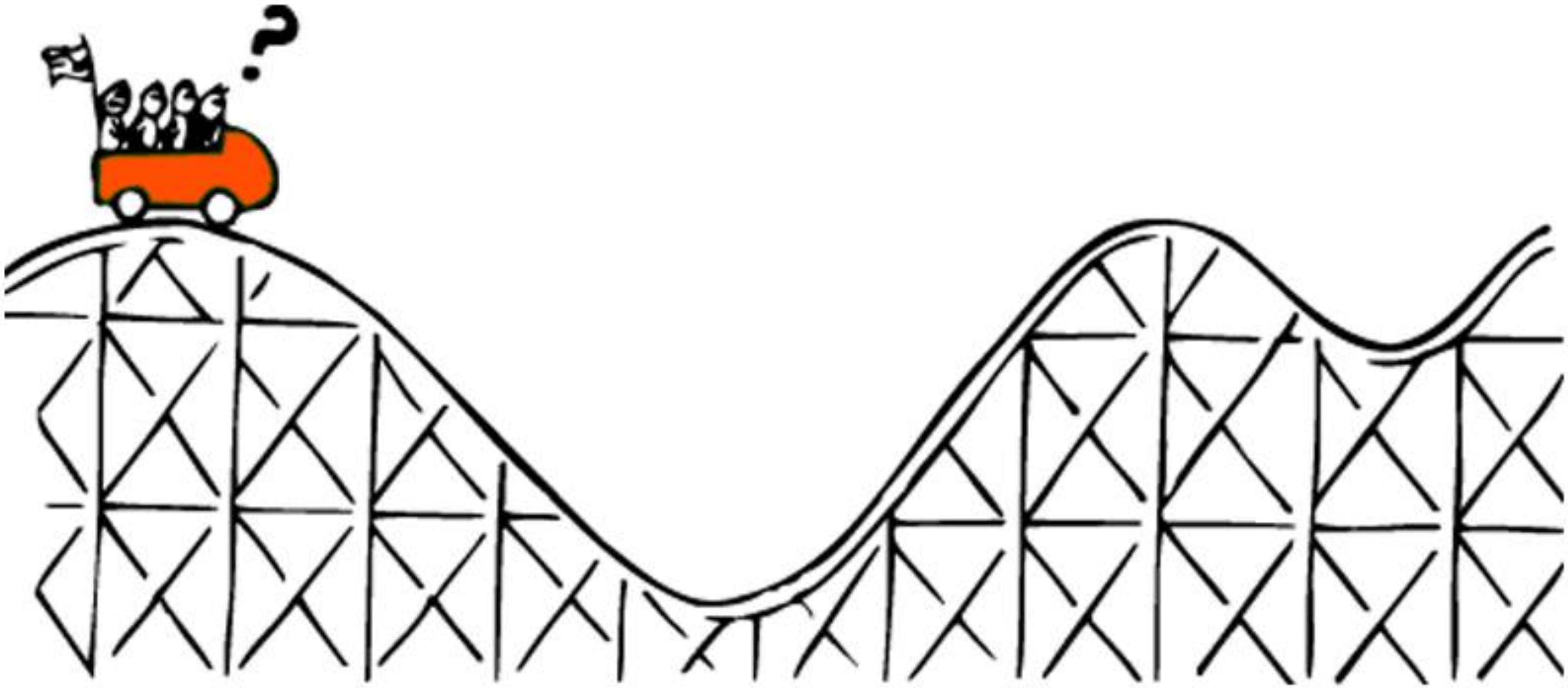
Energy Conservation

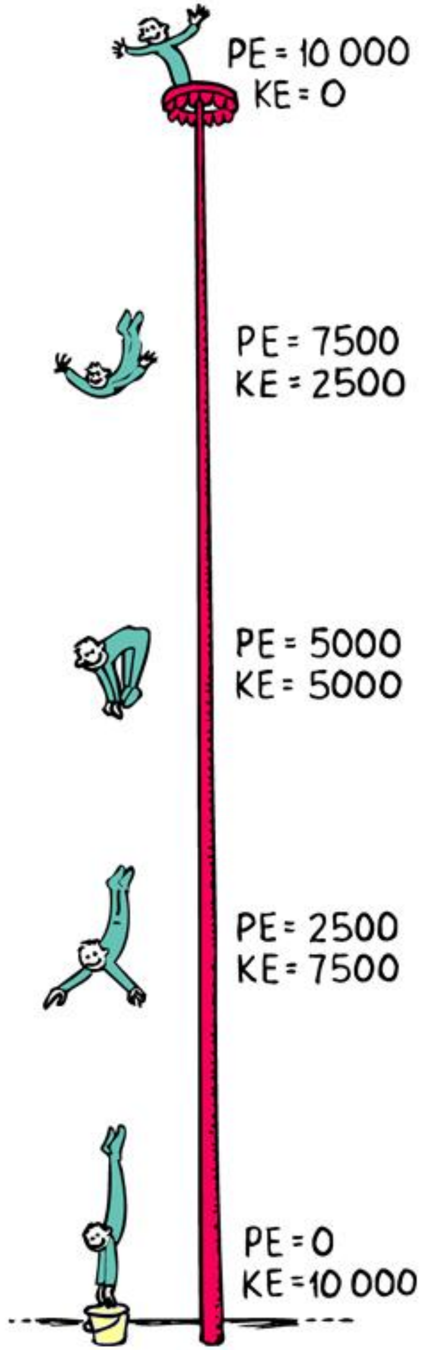
- Energy is constantly transforming, but never "disappears"
- Law of Conservation of Energy: Energy cannot be created or destroyed, only changed from one form to another.

Energy Conservation

- Potential and kinetic energy are constantly transforming back and forth
  - Most of the time during this transformation, some energy is turned to heat and transferred out of the system

Energy Conservation




PE = 10 000
KE = 0
PE = 7500
KE = 2500
PE = 5000
KE = 5000
PE = 2500
KE = 7500
PE = 0
KE = 10 000

Bell Ringer

- Jill has a velocity of 5m/s. If she has a mass of 60kg, what is her kinetic energy?
- If Bob, at 70kg, is standing on top of a 13m high hill. What is his potential energy?

Work-Energy Theorem

- The change in gravitational potential energy of an object is equal to the amount of work needed to change its height
- Therefore:

$$\text{Work} = \Delta PE$$

$$Fd = mgh$$

Work-Energy Theorem

- The KE of a moving object is equal to the work the object is capable of doing while being brought to rest
- Therefore:

$$W = \Delta KE \quad \text{or} \quad Fd = \tfrac{1}{2}mv^2$$

Work-Energy Theorem

- Putting these two ideas together gives us the general Work-Energy Theorem:

If no change in energy occurs, then no work is done. Therefore, whenever work is done, there is a change in energy.

Bell Ringer

- List and give an example of the 6 types of simple machines.

Simple Machines

- Machine: A device used to multiply forces or to change the directions of forces
- There are six types of simple machines:
  - Pulley: Grooved wheels which assist in raising, lowering, or moving an object

Simple Machines

- Lever: A stiff bar which pivots on a support to assist in lifting or moving an object
- Wedge: An object consisting of a slanting side ending in a sharp edge which separates or cuts materials apart
- Wheel and Axle: A wheel with a rod through its center which lifts or moves objects

Simple Machines

- Inclined Plane: A slanting surface connecting a lower level to a higher level
- Screw: An inclined plane wrapped around a rod which holds objects together or lifts materials

Bell Ringer

- What is an example of a 100% efficient machine?

Mechanical Advantage

- <u>Mechanical Advantage:</u> A machine's ratio of output force to input force

$$\text{Mechanical Advantage} = \frac{\text{Output Force}}{\text{Input Force}}$$

  - i.e. A machine which outputs 80 N for every 10 N you put in has a mechanical advantage of 8.
  - Note that the load will move only 1/8 of the input distance

Efficiency

- **Efficiency:** A machine's ratio of useful work output to total work input

$$\text{Efficiency} = \frac{\text{Useful Work Output}}{\text{Total Work Input}}$$

- Efficiency is expressed as a percent
  - i.e.) An efficiency result of 0.25 means 25% efficiency

Efficiency

- Ideal machines have 100% efficiency
  - This means that all of the energy put into the machine exits as useful energy
- All other machines will ALWAYS have an efficiency of less than 100%
  - A machine cannot output more work than is put into it

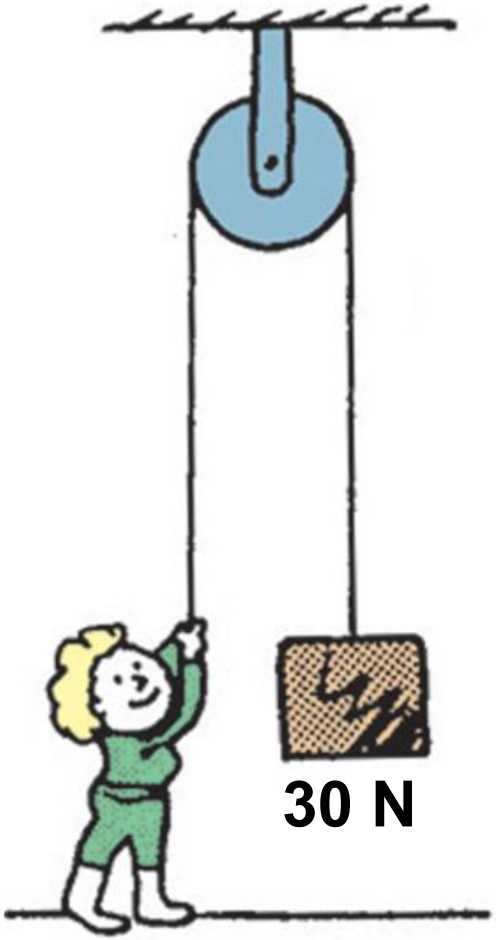
Pulleys

- Single Pulley:
  - Changes the direction of a force exerted by a rope or cable
- System of pulleys:
  - Multiplies input forces, creating large output forces

Pulleys

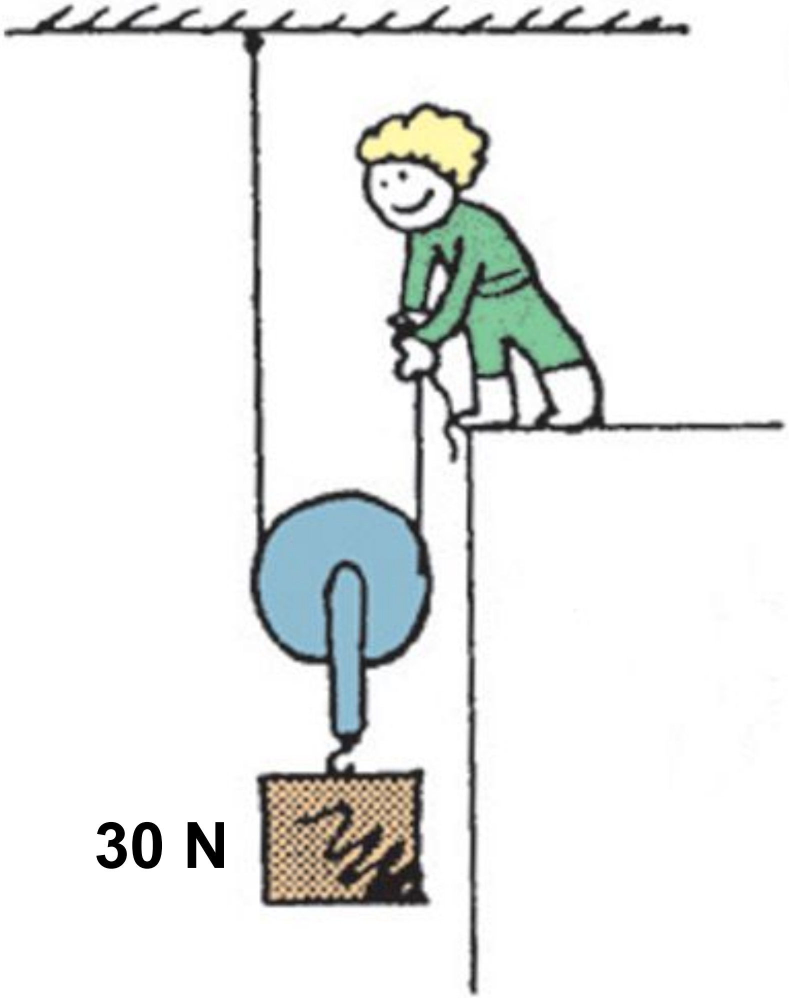
- Each supporting strand of rope holds an equal fraction of the weight
- Tension in this cable is the same throughout its entire length
  - Input force = tension in each supporting segment of the cable
  - Mechanical advantage = number of supporting strands

Pulleys



Input force = 30 N

Pulleys



Input force = 15 N

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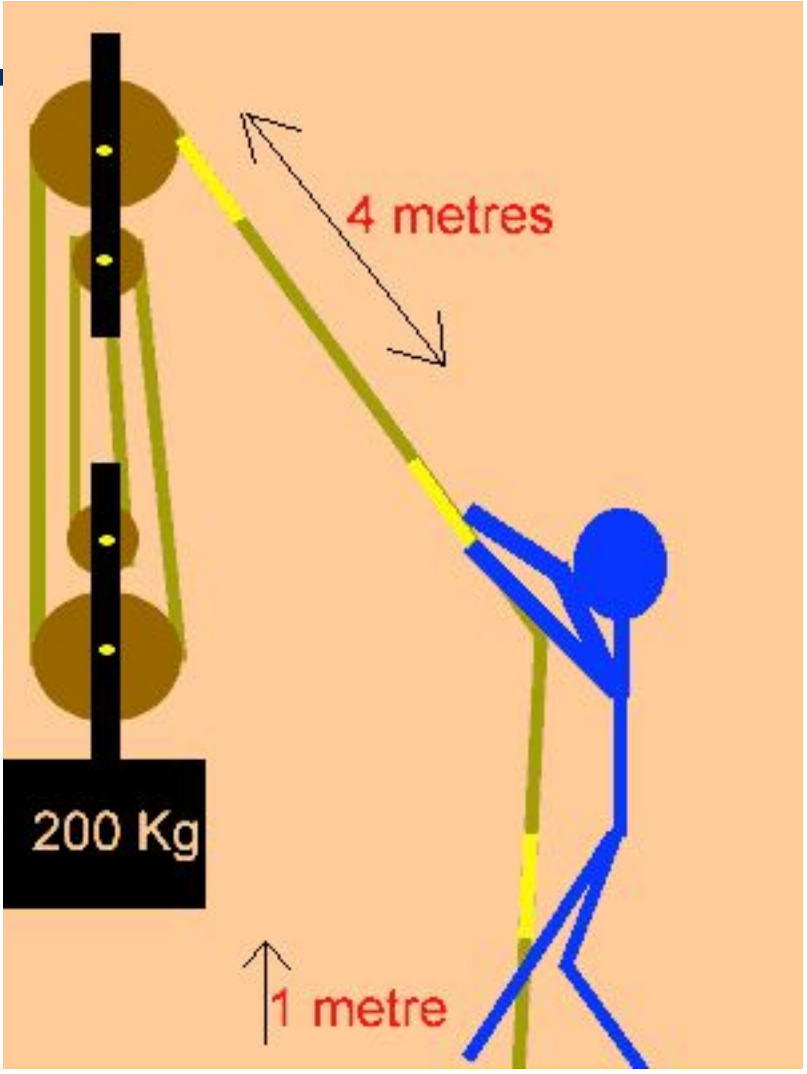
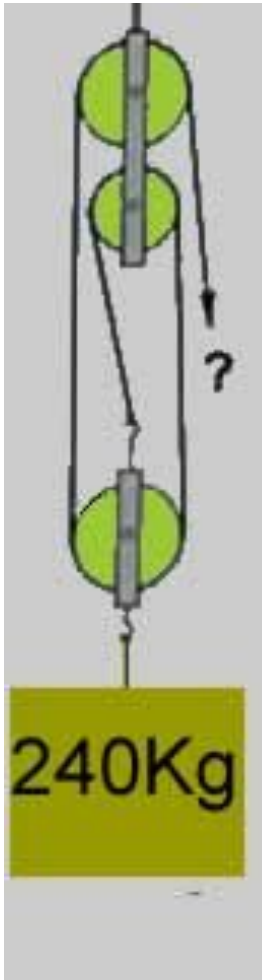
- How many supporting strands are there ?
- What is the Mechanical advantage here equal to?
- What is the input force required to lift the 200kg object?



More Practice

- What is the minimum effort that must be applied to lift the load?
- For every 2 meters the rope is pulled through what height does the load rise off the ground?
- What is the mechanical advantage?



LEVERS

Levers

- A simple machine made of a bar which turns about a fixed point
  - Fulcrum: The pivot point of a lever
- Change the direction of or multiply input forces

Three Types of Levers

- Type 1 Lever: Fulcrum lies between the input force and the load
  - i.e.) A seesaw
- Type 2 Lever: The load lies between the fulcrum and the input force
  - i.e.) A pry bar

Three Types of Levers

- Type 3 Lever: The input force lies between the fulcrum and the load
  - i.e.) Your forearm pivoting about your elbow

Lever Lab

Levers

- If friction is small enough to neglect:

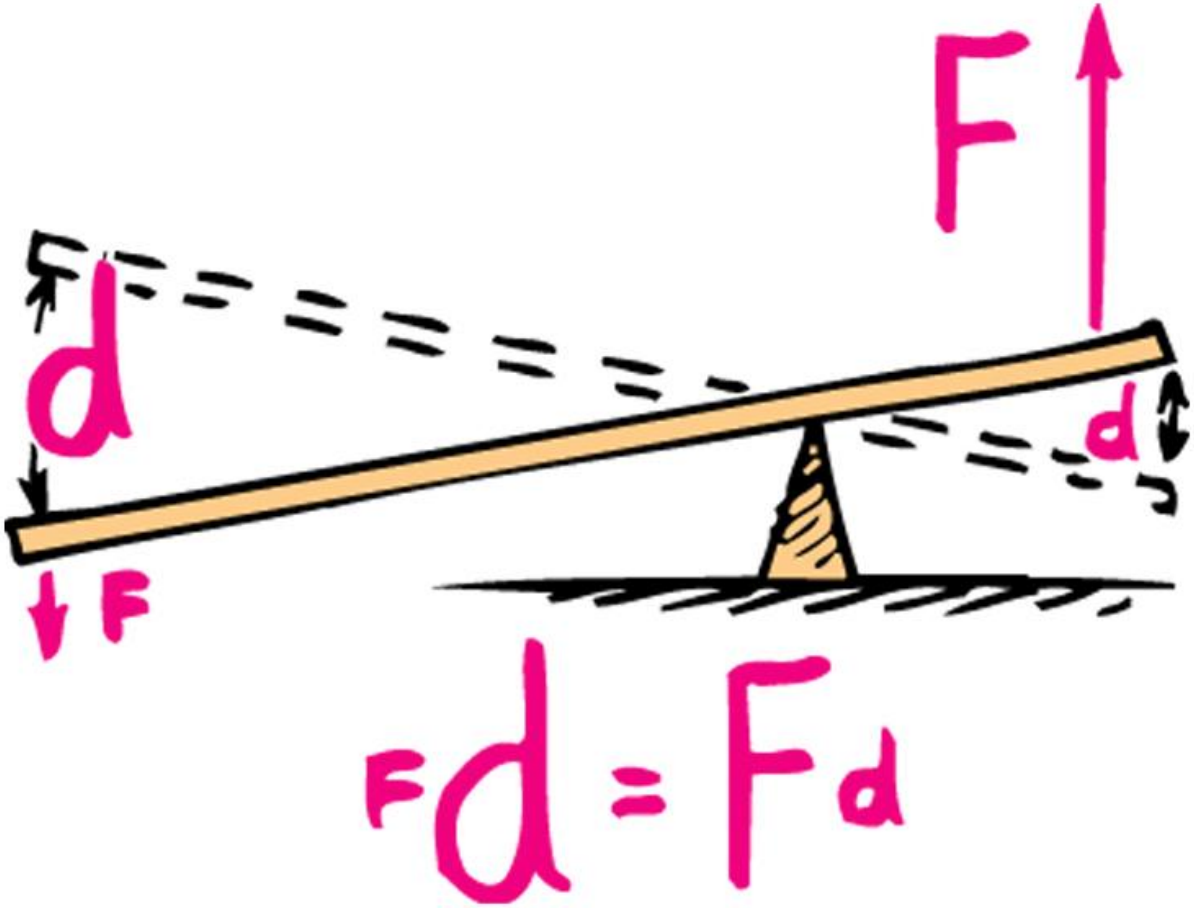
Work Input = Work Output

or

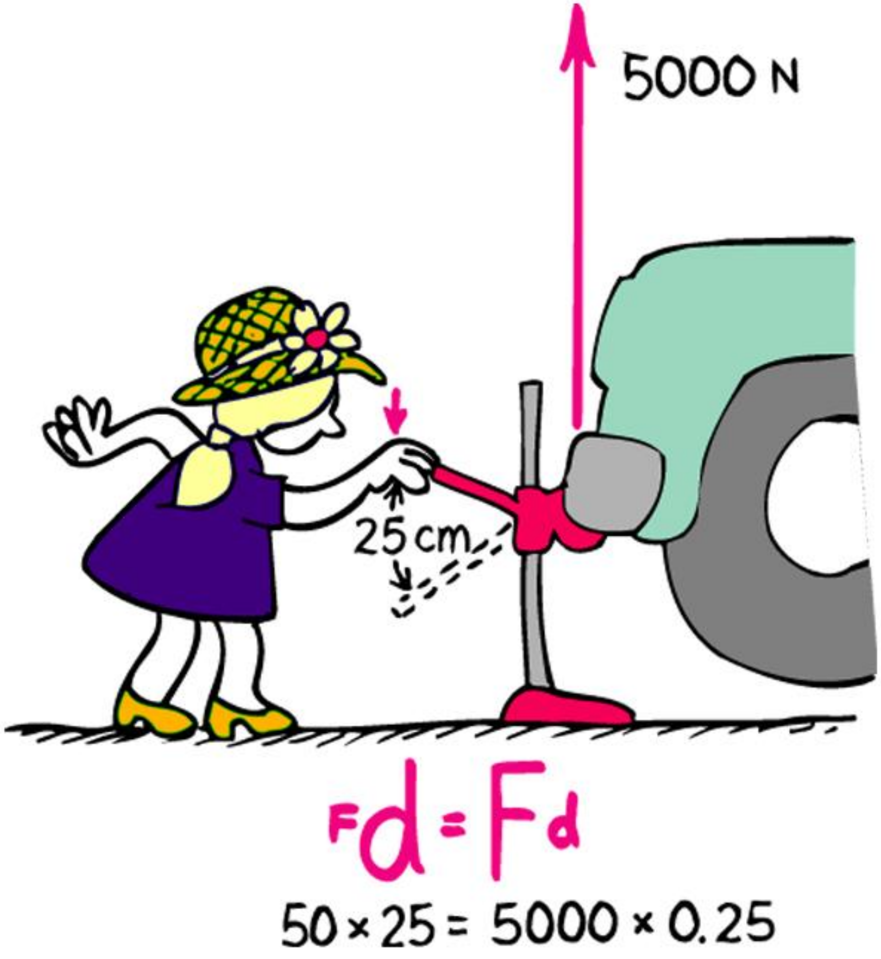
$$(Fd)_{input} = (Fd)_{output}$$

- Therefore: A small input force over a large distance will output a large force over a small distance

Levers



Levers



Wedge

- Wedge: An object consisting of a slanting side ending in a sharp edge which separates or cuts materials apart
  - i.e. knife

Wheel and Axel

- Wheel and Axle: A wheel with a rod through its center which lifts or moves objects
  - ie: Cart

Inclined Plane

- Inclined Plane: A slanting surface connecting a lower level to a higher level
  - i.e. Accessibility ramp

Screw

- Screw: An inclined plane wrapped around a rod which holds objects together or lifts materials

Compound Machine

- Compound machines use two or simple machines to complete a task
- Examples?
  - Rube Goldberg Device

Bell Ringer

- How much energy is transferred in lifting a 5 kg mass 3m?
- What is the work energy theorem?