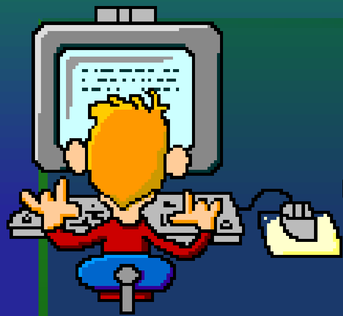
# Work, Power, & Machines

Hold a book out in front of you…your arms are getting tired…is this work?

# What is work ?



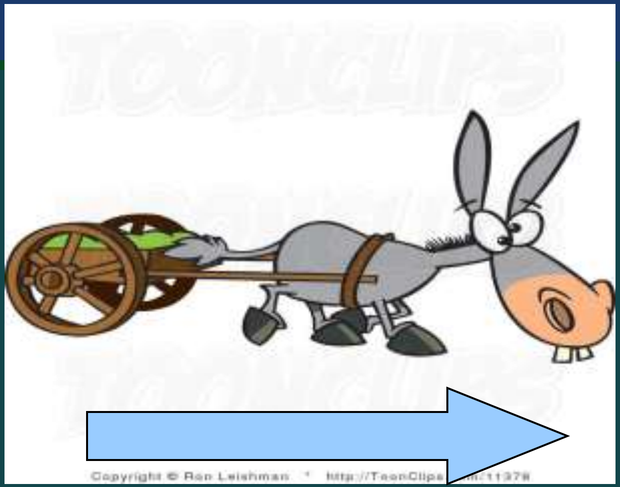


- WORK: Using a force to move an object a distance (in the same direction).

# Calculating Work

## Work = Force x Distance

- The force acts in the direction of the movement.



# No Distance…No Work

- *No work is done when you stand in place holding an object.*

Example: Hold a 5N pan of chocolate brownies, waiting for your friend to open the door. You have not moved the pan.

W = F x D

work = 5N x 0m = 0

# Is work being done or not?

- Mowing the lawn — YES
- Weight-lifting — YES

- Pushing against a locked door — NO

- Swinging a golf club — YES
- Hanging from a chin-up bar — NO

# *The Joule – the unit we use for work (and ENERGY!)*

- One Newton of Force moving 1 meter is known as a *joule* (J).
- Named after British physicist James Prescott Joule.

# Calculating Work

- If this kid pushed the other kid across the room 10 meters with 5N of force, how much work is done?

- W=F x d
- W= 5 x 10
- 50 Joules

Mean little thing!!

# Another Work Calculation

- This little chicken pulled her eggs 20 meters and did 100 Joules of work. How much force did she use?
- W=F x d
- 100= F x 20
- F= 5N

Cute little thing!!

# Power


- **How quickly** work is done.
  - ***Involves time***

Amount of work done per unit time.

$$P = \frac{\text{Work}}{\text{Time}}$$

# The Watt – the unit of power

- A unit named after Scottish inventor James Watt.
- Invented the steam engine.
- $P = W/t$
  - Joules/second
  - 1 watt = 1 J/s

# See if you can figure this out…

Talia and Chris have the same size yards. Talia can mow her yard in 1 hour with 30N Force, but it takes Chris two hours to mow his yard with 30N of force.

1. Who did more work?
2. Who used more power?

They both did the same amount of work, but Talia used more power!

# watts

- Used to measure power of light bulbs and small appliances
- An electric bill is measured in kW/hrs.
- 1 kilowatt = 1000 W

A train pulls a load 20 meters with 3000N of force. How much work is done?

W=Fd

W= 3000 x 20 = 60,000 Joules

A woman lifts a baby with 5N of force. She did 30J of work. How far did she lift the baby up?

W= Fd

30= 5d

30/5 =d

D=6 meters

A kid pushed a wagon in 30 seconds with 20 N of force. He pushed it a total of 10 meters before he gave up.

How much work did he do?

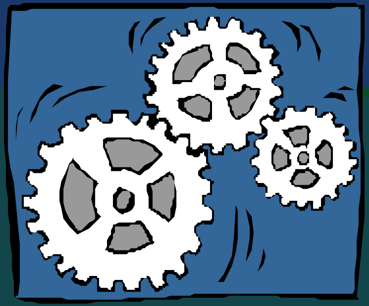
W=20x10 = 200 J

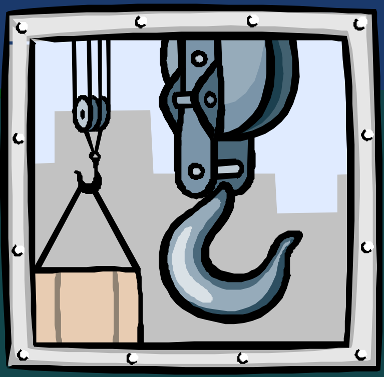
How much power did he use?

P=W/t   P=200/30     P= 6.67 W

# Machines

- A device that makes work <u>easier</u>.
- A machine can change the size, the direction, or the distance over which a force acts.





# Forces involved:

- Input Force
  - $F_I$
  - Force applied <u>to</u> a machine

Output Force

$F_O$

Force applied <u>by</u> a machine

# Two forces, thus two types of work

- Work Input

✓ work done <u>on</u> a machine

=Input force x the distance through which that force acts (input distance)

Work Output

Work done <u>by</u> a machine

=Output force x the distance through which the resistance moves (output distance)

# Can you get more work out than you put in?

- Work output can never be greater than work input.

# Mechanical Advantage –

- The number of times a machine multiplies the input force.

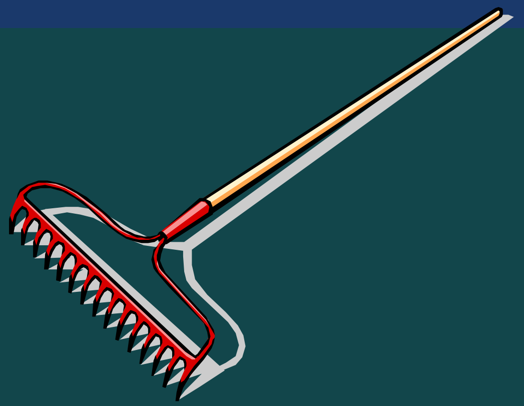
MA = output force/input force

# Different mechanical advantages:

- MA equal to one. (output force = input force)
- Change the direction of the applied force only.

Mechanical advantage less than one

An increase in the distance an object is moved ($d_o$)



# Efficiency

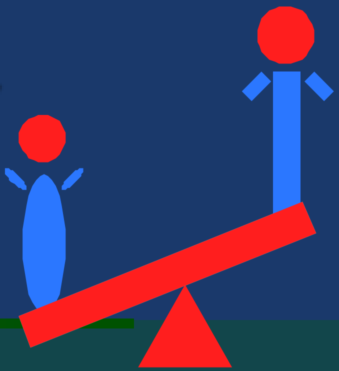
- Efficiency can never be greater than 100 %. Why?
- Some work is always needed to overcome friction.
- A percentage comparison of work output to work input.
  - work output ($W_O$) / work input ($W_I$)

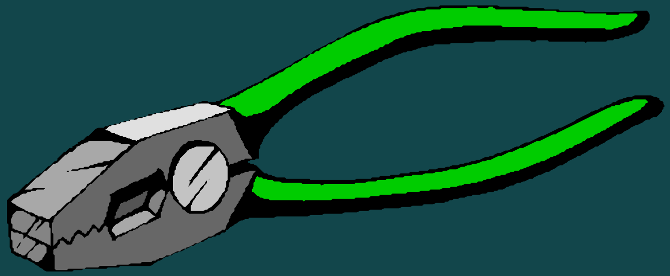
# 1. THE LEVER

- A bar that is free to pivot, or move about a fixed point when an input force is applied.
- *Fulcrum* = the pivot point of a lever.
- There are three classes of levers based on the positioning of the effort force, resistance force, and fulcrum.

# First Class Levers

- Fulcrum is located between the effort and resistance.
- Makes work easier by multiplying the effort force AND changing direction.
- Examples:





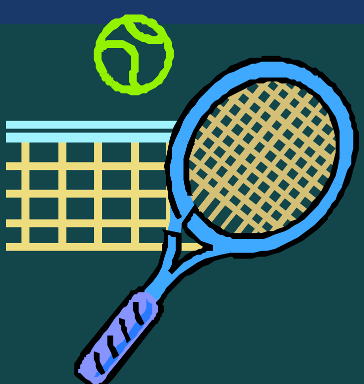
# Second Class Levers

- Resistance is found between the fulcrum and effort force.
- Makes work easier by multiplying the effort force, but NOT changing direction.
- Examples:

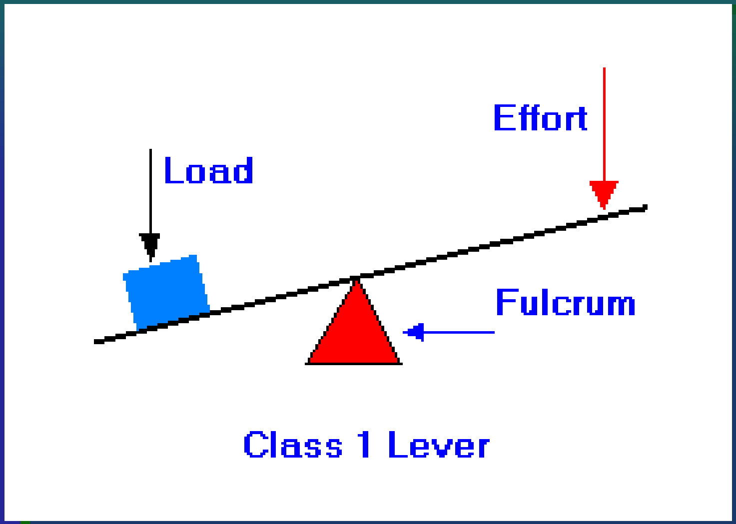
# Third Class Levers

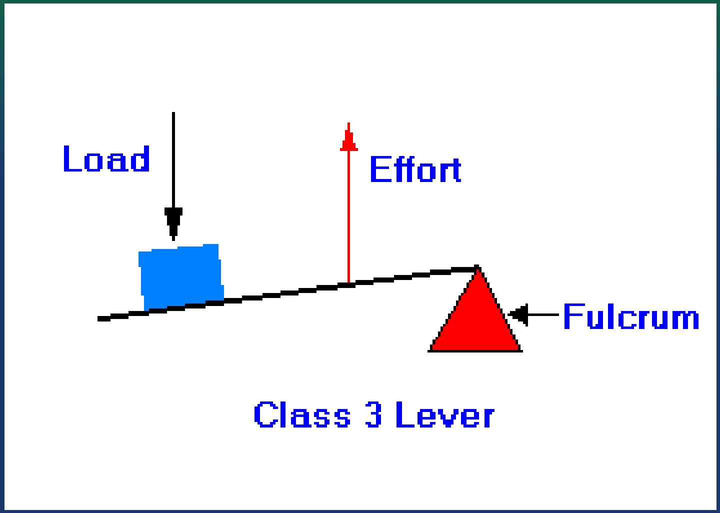
- Effort force is located between the resistance force an the fulcrum.

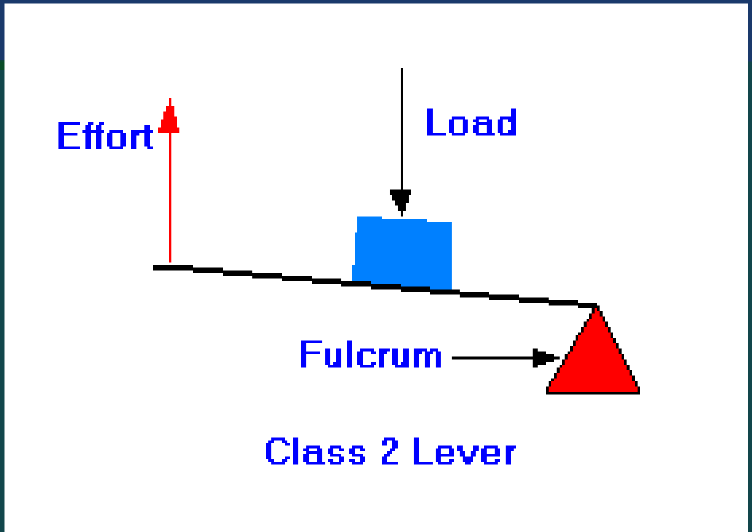
- Does NOT multiply the effort force, only multiplies the distance.
- Examples:



# Levers!!!!!!!!!!!

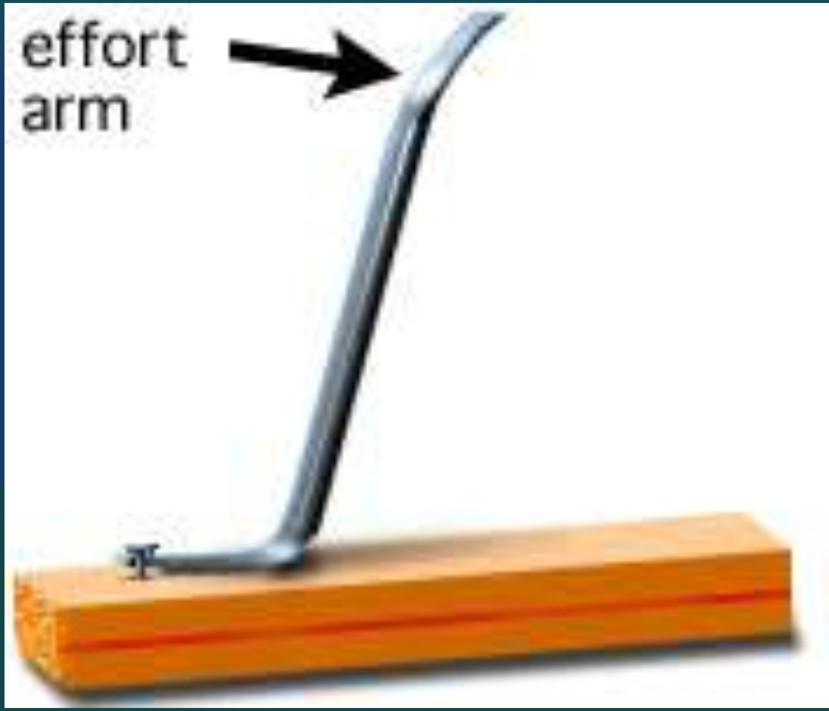

Effort
Load
Fulcrum
Class 1 Lever


Load
Effort
Fulcrum
Class 3 Lever


Effort
Load
Fulcrum
Class 2 Lever

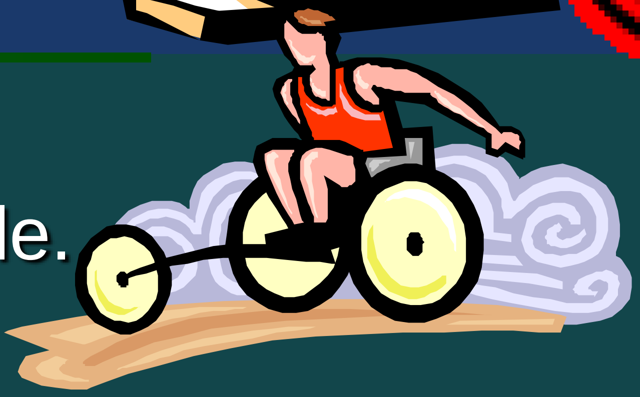
# Mechanical advantage of levers.

- Ideal = input arm length/output arm length
- *input arm* = distance from input force to the fulcrum
- *output arm* = distance from output force to the fulcrum



# 2. The Wheel and Axle

- A lever that rotates in a circle.
- A combination of two wheels of different sizes.
- Smaller wheel is termed the axle.
- IMA = radius of wheel/radius of axle.

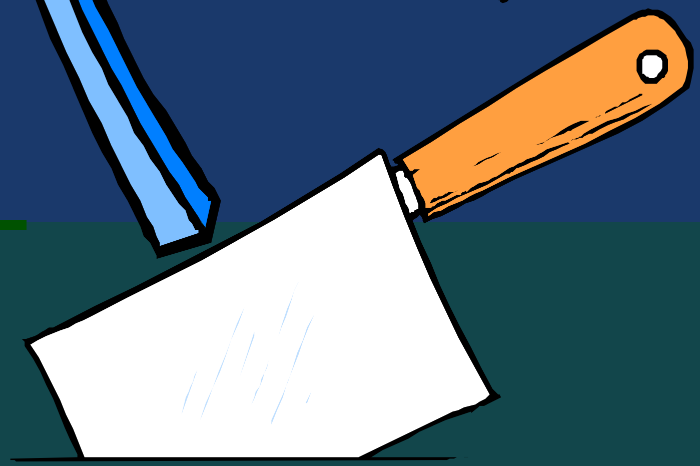


# 3. THE INCLINED PLANE

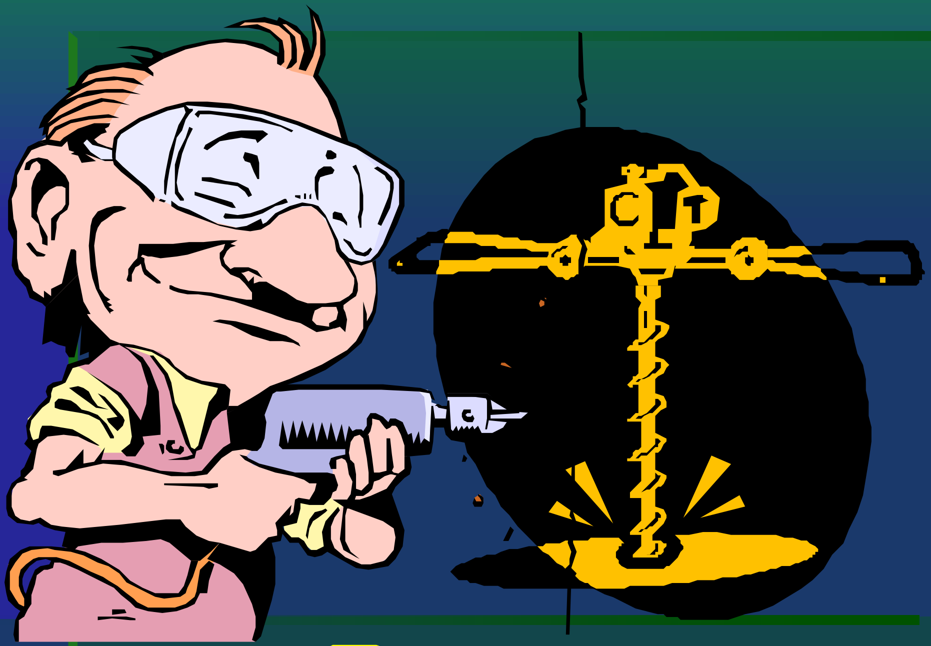
- A slanted surface used to raise an object.
- Examples: ramps, stairs, ladders
- IMA = length of ramp/height of ramp
- Can <u>never</u> be less than one.

# 4. THE WEDGE

- An inclined plane that moves.
- Examples: knife, axe, razor blade
- Mechanical advantage is increased by sharpening it.

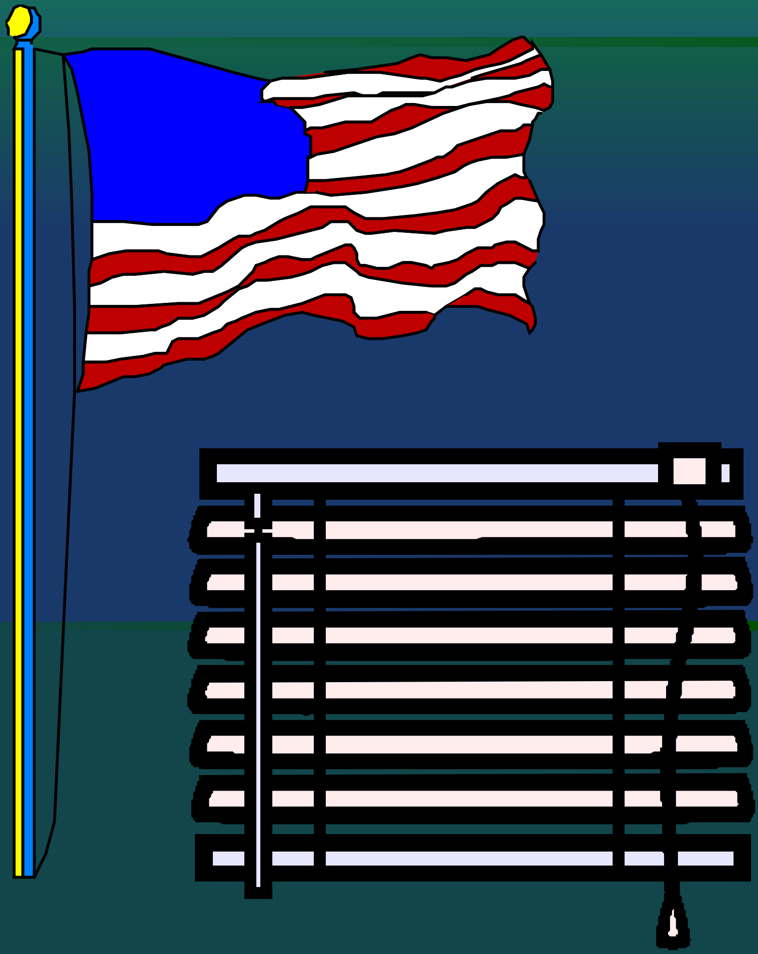


# 5. The Screw



- An inclined plane wrapped around a cylinder.
- The closer the threads, the greater the mechanical advantage
- Examples: bolts, augers, drill bits

# 6. THE PULLEY



- A chain, belt , or rope wrapped around a wheel.
- Can either change the direction or the amount of effort force
- Ex. Flag pole, blinds, stage curtain

# Pulley types

- FIXED
- Can only change the direction of a force.
- MA = 1

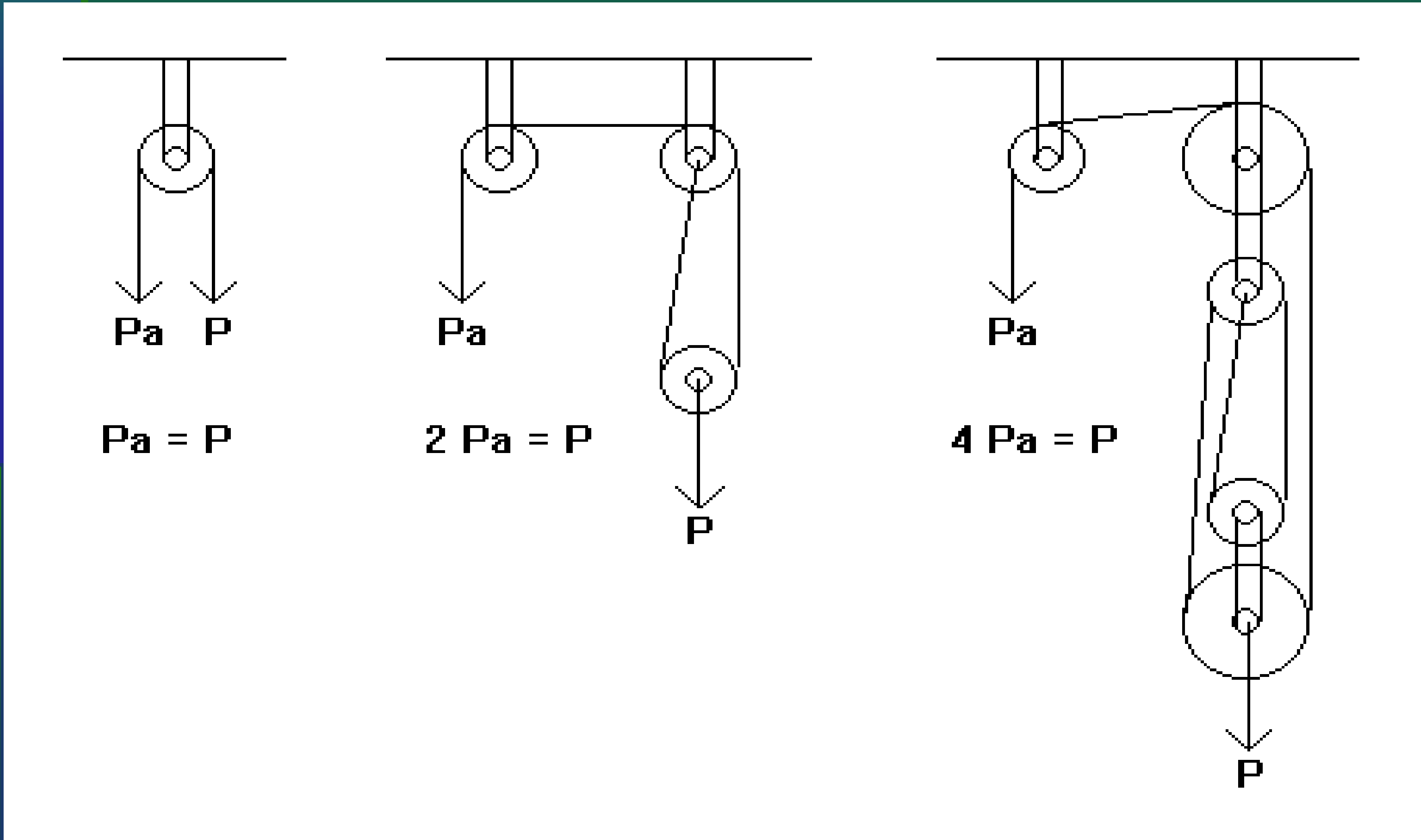
MOVABLE

Can multiply an effort force, but cannot change direction.

MA > 1

**IMA = number of supporting ropes**

# MA = Count # of ropes that apply an upward force (note the block and tackle!)



# Compound Machines

- A combination of two or more simple machines.
- Cannot get more work out of a compound machine than is put in.