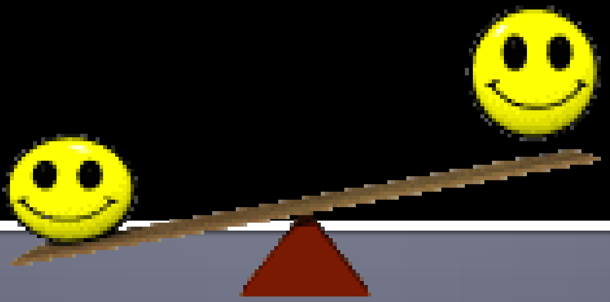
11.6
Simple Machines

Lever Family
(Levers, Wheel & Axle, Pulleys)

Simple Machines

Levers



Levers

- A board that pivots on a fixed point.
- A lever is a simple machine used for magnifying a force.
- There are 3 classes of levers.

Examples:

- Teeter-totter
- Balance or Scale
- Shovel.

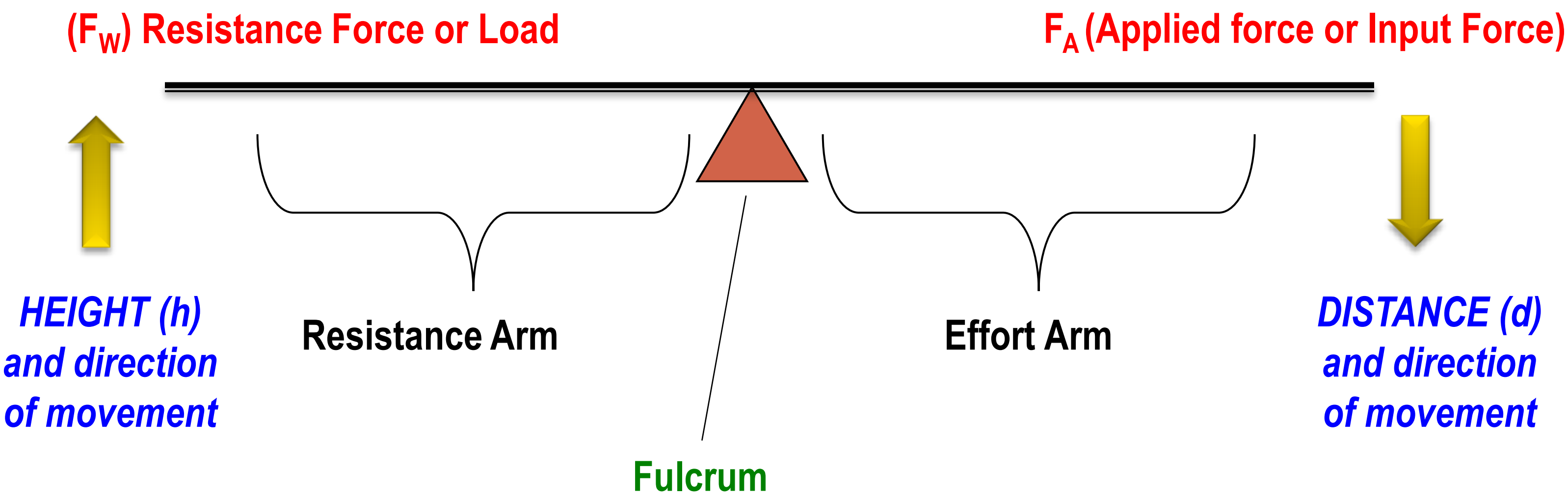
Levers

All levers have three parts:

1. **Resistance Force, Output Force or Load (F_W)**
   What you are trying to move or lift.
2. **Applied Force or Input Force (F_A)**
   The work done on the lever.
3. **Fulcrum or Pivot Point**

Levers

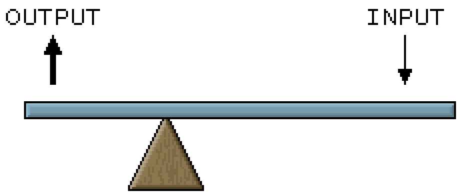
All levers have three parts:



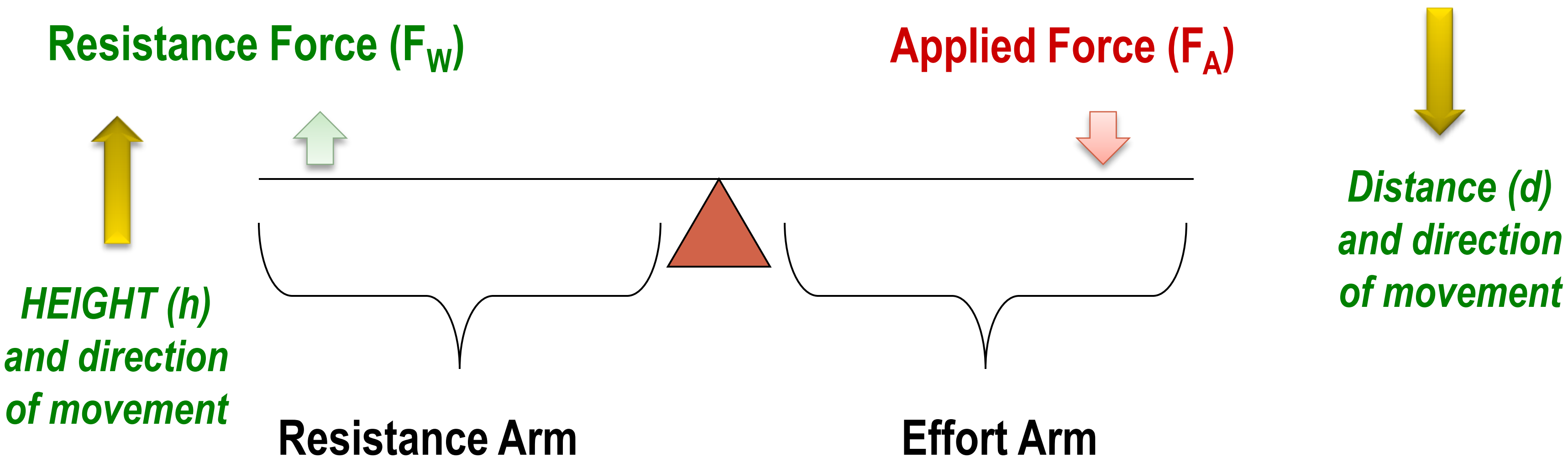
1st Class Lever

1st Class Lever

- The Fulcrum is located between the Applied Force (Input) and the Resistance Force (Output).
- The applied force and the resistance force move in opposite directions.
- The applied force pushes down in order to lift the resistance or load
- Think of a see-saw. One end will lift an object up just as far as the other end is pushed down.



1st Class Lever



Mechanical Advantage:

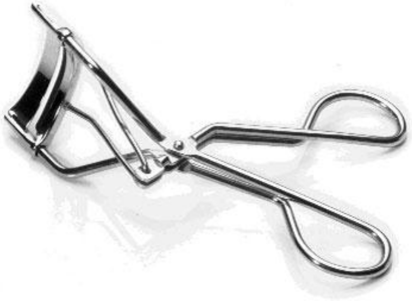
I.M.A: = d / h

A.M.A: = F_W / F_A

1st Class Lever Examples

Examples of 1st class levers:

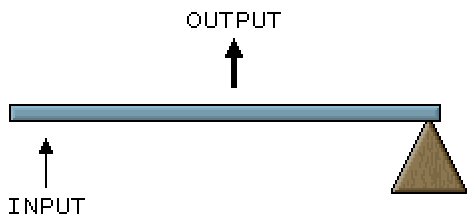
1. **Pliers, Scissors**
2. **Triple beam balance**
3. **Hedge/Pruning shears**
4. **Pry-Bar, Crow Bar**
5. **Eyelash Curler**



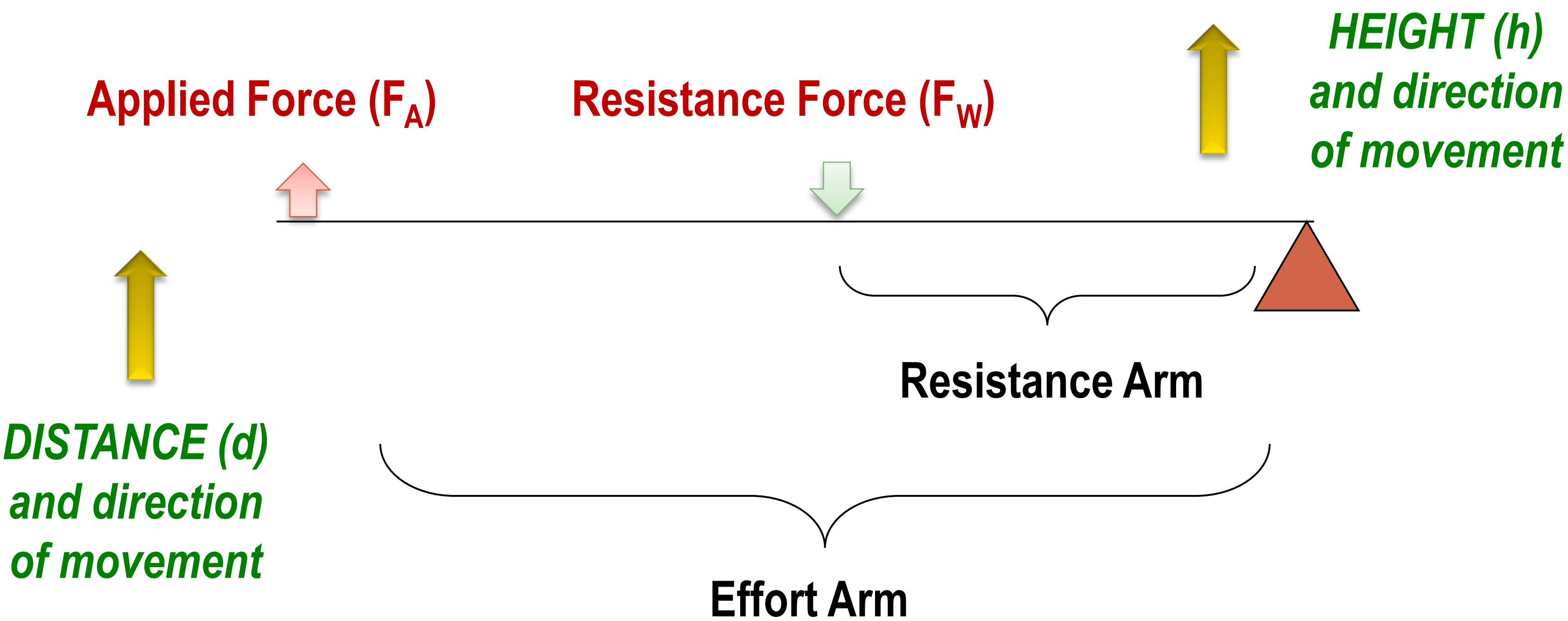
2nd Class Lever

2nd Class Lever

- The resistance force is between the applied force and the fulcrum.
- The fulcrum is at one end of the lever.
- The fulcrum is usually closer to the resistance force.
- Think of a wheelbarrow. The long handles of a wheel barrow are really the long arms of a lever.



2^{nd} Class Lever



Mechanical Advantage:

I.M.A: = d / h

A.M.A: = F_W / F_A

2^{nd} Class Lever Examples

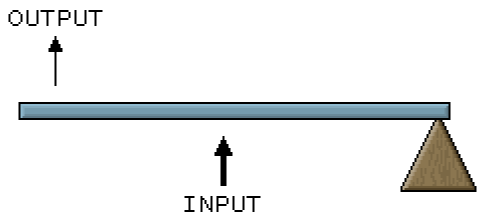
Examples of 2^{nd} class levers:

1. Wheelbarrow
2. Nutcracker
3. Handle on fingernail clippers
4. Gas Pump Handle
5. Pop Bottle Opener

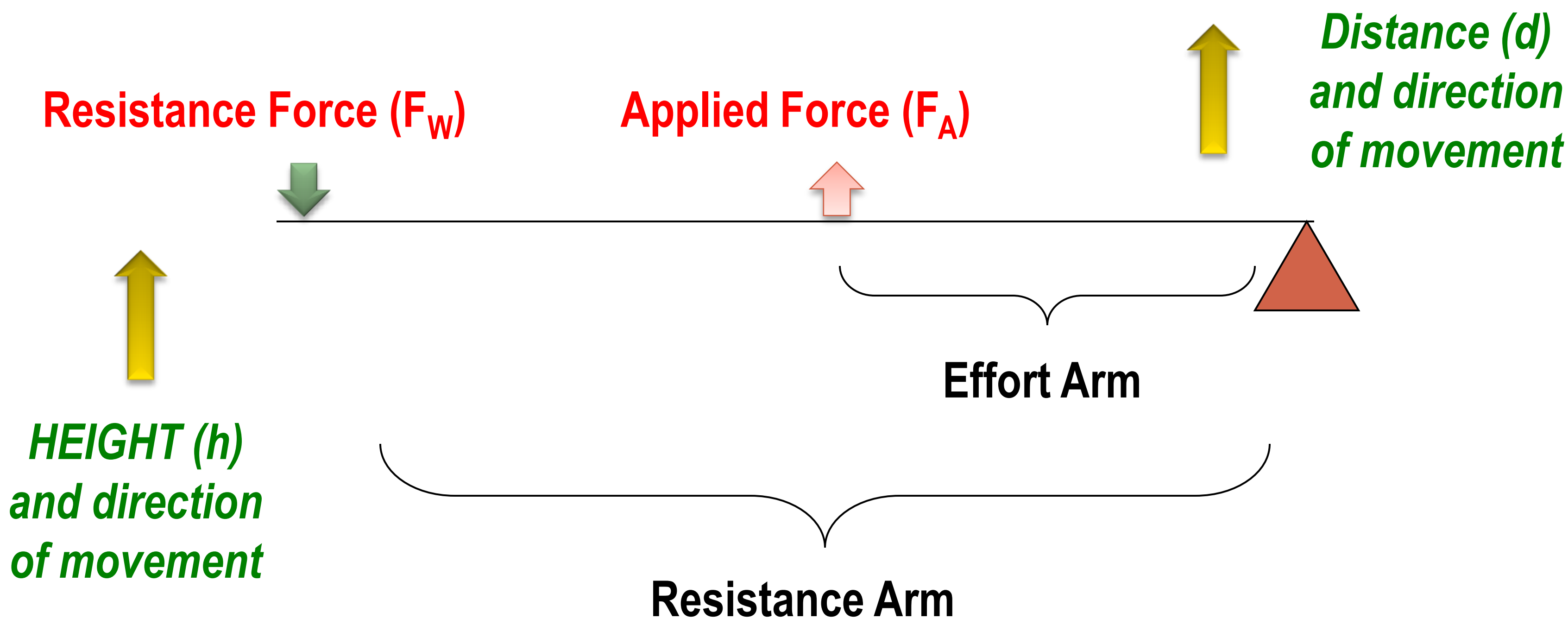
3rd Class Lever

- The applied force is between the resistance load and the fulcrum.

- Think of a fishing pole. When the pole is given a tug, one end stays still but the other end flips in the air catching the fish.



3rd Class Lever

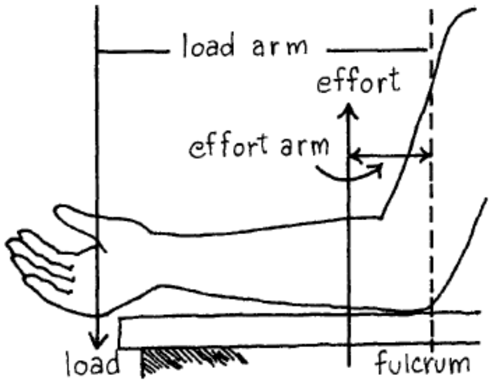


Mechanical Advantage:

I.M.A: = d / h

A.M.A: = F_W / F_A

3rd Class Lever Examples



Examples of 3rd class levers:

1. Shovel
2. Human Forearm
3. Mouse Trap
4. Fishing Pole

Lever Example Problems

Example #1

A 250 N crate is picked up by pushing on a lever with 50 N of force. Find the AMA of the lever.

Example #2

A lever system with 80% mechanical efficiency gives an output work force of 10 N. What is the input force?

Lever Example Problems

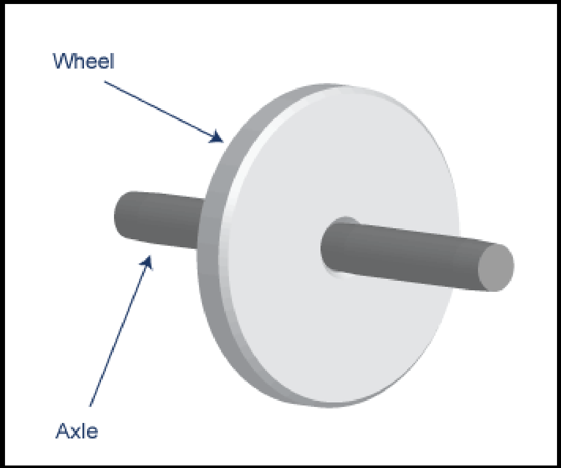
Example #3

To pry a nail out of a wall, you can apply a force of 50 N to the hammer. The hammer applies a force of 650 N to the nail. What is the mechanical advantage of the hammer?

Example #4

You do 42 J of work with scissors. If the scissors do 40 J of work, what is the efficiency of the scissors?

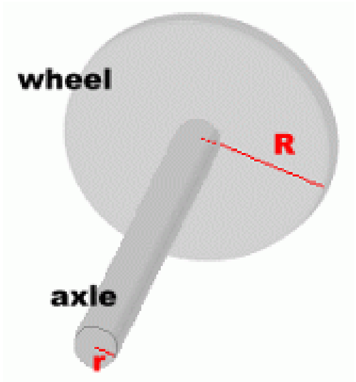
Simple Machines
Wheel and Axle



Wheel and Axle

The Wheel & axle is a modified lever:

- The center of the axle acts as a fulcrum – making the wheel a lever that rotates around in a circle.
- The axle is a rod that goes through the wheel which allows the wheel to turn.
- 2 Configurations:
  1. Wheel drives the axle
  2. Axle drives the wheel



Wheel and Axle

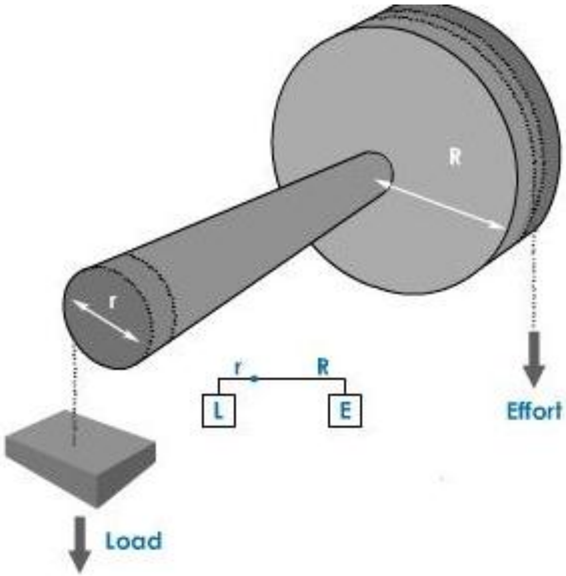
Examples of Wheel & Axles:

1. Screwdriver (Wheel driving axle)
2. Door Knob (Wheel driving axle)
3. Windmill (Wheel driving axle)
4. Ceiling Fan (Axle drives wheel)
5. Rear Bike Wheel (Axle drives wheel)

Wheel and Axle

Mechanical Advantage:

I.M.A: = R_{WHEEL} / r_{AXLE}
A.M.A: = F_{OUT} / F_{IN}



R_{WHEEL} = Radius of the Wheel

r_{axle} = Radius of the axle

Wheel and Axle Example Problems

Example #1

You do 1260 J of work with a wheel and axle. If the wheel and axle does 1200 J of work, what is the efficiency of the wheel and axel?

Example #2

A wheel and axle system has a mechanical advantage of 3 and an axle radius of 30 cm. What is the radius of the wheel? (90 cm)

Wheel and Axle Example Problems

Example #3

The radius of a wheel is 100 cm and that of its axle is 50 cm. What is its mechanical advantage?

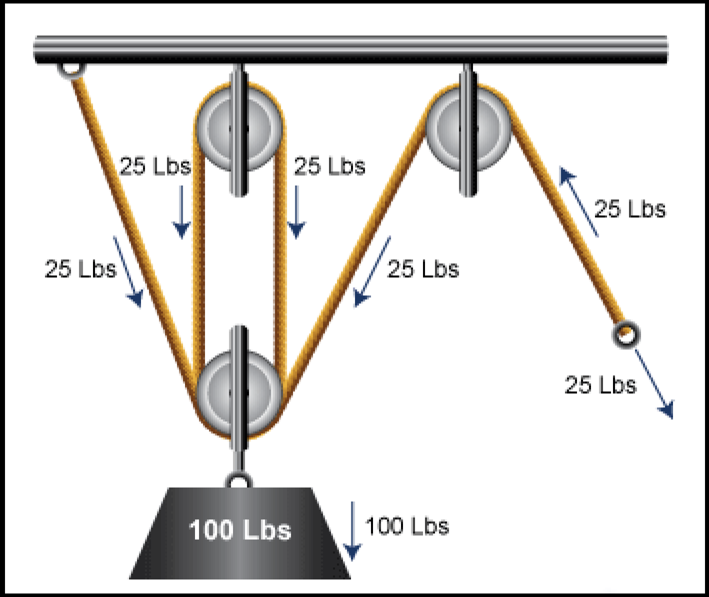
Example #4

An industrial water shutoff valve is designed to operate with 40 lb of effort force. The valve will encounter 250 lb of resistance force applied to a 1.25 in. diameter axle.

a. Sketch the wheel and axle system described above
b. What is the required actual mechanical advantage of the system
c. If the system is frictionless, what is the diameter of the wheel?

Simple Machines

Pulleys



Pulleys

A simple machine made with a rope, belt or chain wrapped around a grooved wheel.

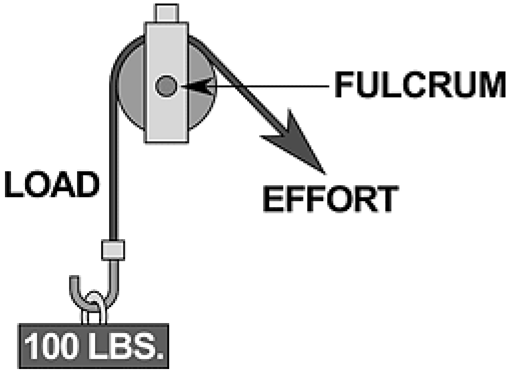
Two types of pulleys:

1. Fixed (Stationary, attached to support)
2. Moveable (Pulley moves along the rope)

Fixed Pulley

Fixed Pulley:

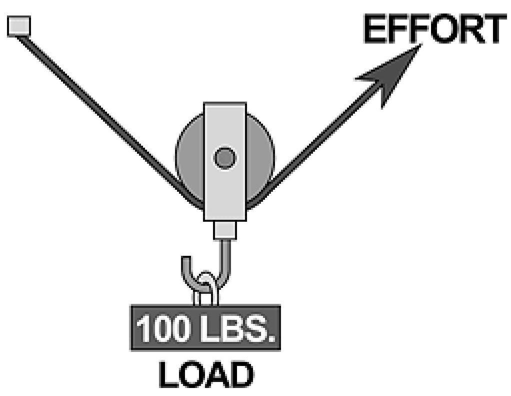
- Wheel attached to surface.
- Changes the direction of the applied force (does not multiply force).
- NO mechanical advantage – same amount of force is required.



Moveable Pulley

Movable Pulley:

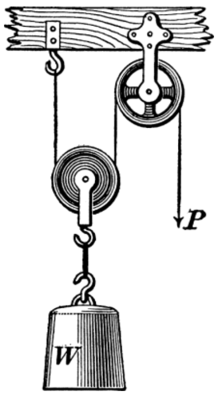
- Pulley moves along the rope.
- Wheel supports the load.
- Effort is in the same direction as movement.
- Reduces the forces needed to move an object.

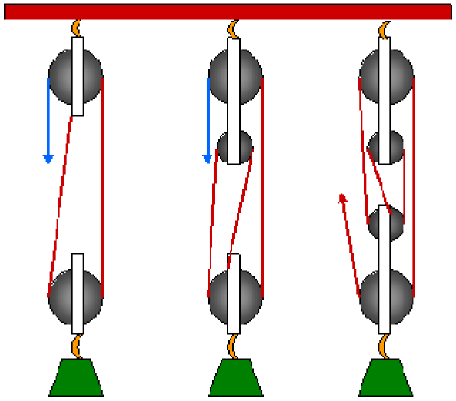


Combined Pulleys

Combined Pulleys:

- A combination of fixed and movable pulleys.
- Has at least two wheels.
- The more complex the pulley, the applied force (effort) needed to move the object decreases.





Pulleys

Mechanical Advantage:

A.M.A = F_W / F_A

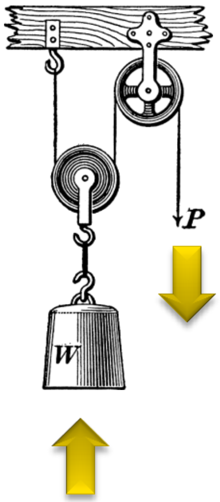
The I.M.A can be determined by counting the number of upward supporting ropes which hold up the resistance. Only count the rope if you are pulling up.

Pulleys

Mechanical Advantage:

If the # of strands are not shown, use the following formula:

I.M.A.= d / h



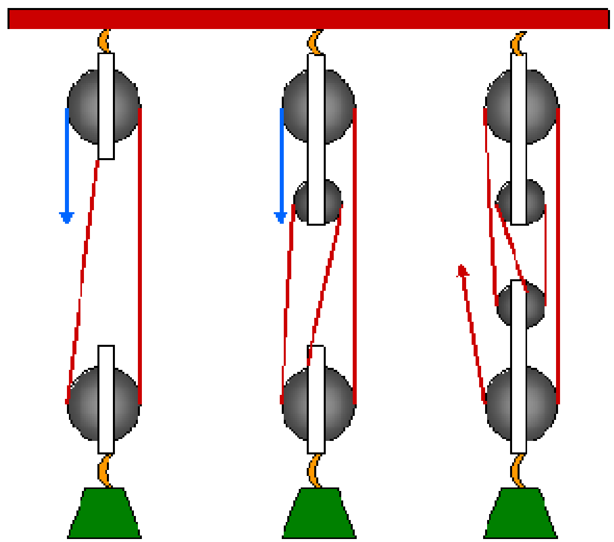
DISTANCE (d) and direction of movement

HEIGHT (h) and direction of movement

Pulleys

Mechanical Advantage:

What is the I.M.A of each pulley system?



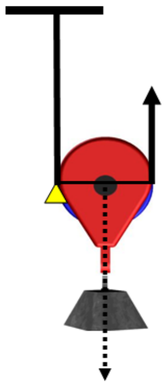
IMA=2 *IMA=3* *IMA=5*

Pulley Example Problems

Example #1

Carmela is using a pulley to lift an 100 pound anvil (Why an anvil? We don't know).

a. **What is the IMA of this pulley system?**
b. **If Carmela has to exert 60 pounds to lift the anvil, what is the AMA?**
c. **What is the efficiency?**



Pulley Example Problems

Example #2

Susie is using a pulley to lift another anvil.

a. What is the I.M.A. of this pulley system?
b. If Katie has to exert 120 pounds, what is the AMA?
c. What is the efficiency?
d. Why bother using this type of pulley?