Work, Energy and Power

I. Work

- Work is a transfer of energy.
- Energy is transferred to/from the object as a force changes an object's position or motion.
- No work is done if the object's motion does not

I. Work

- No work is done if the object’s motion does not change.
- $W = Fd \cos \theta$

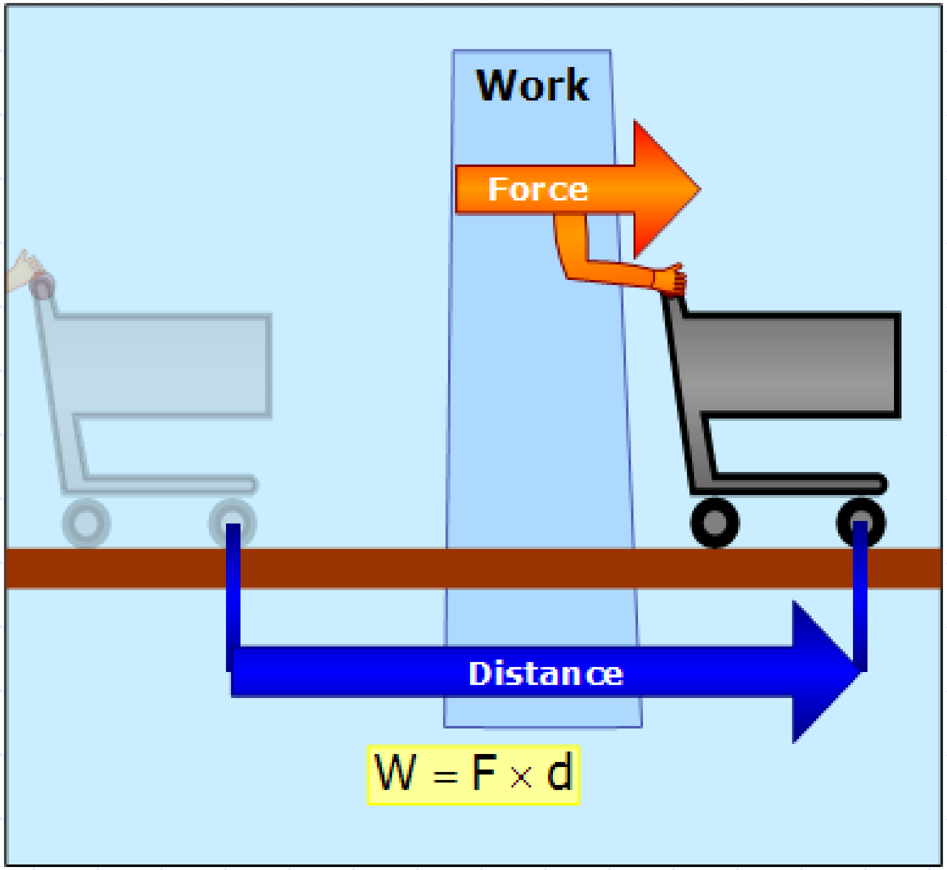
- The angle is measured between the force and the motion.

I. Work

- Only components of a force that are parallel to the displacement do work

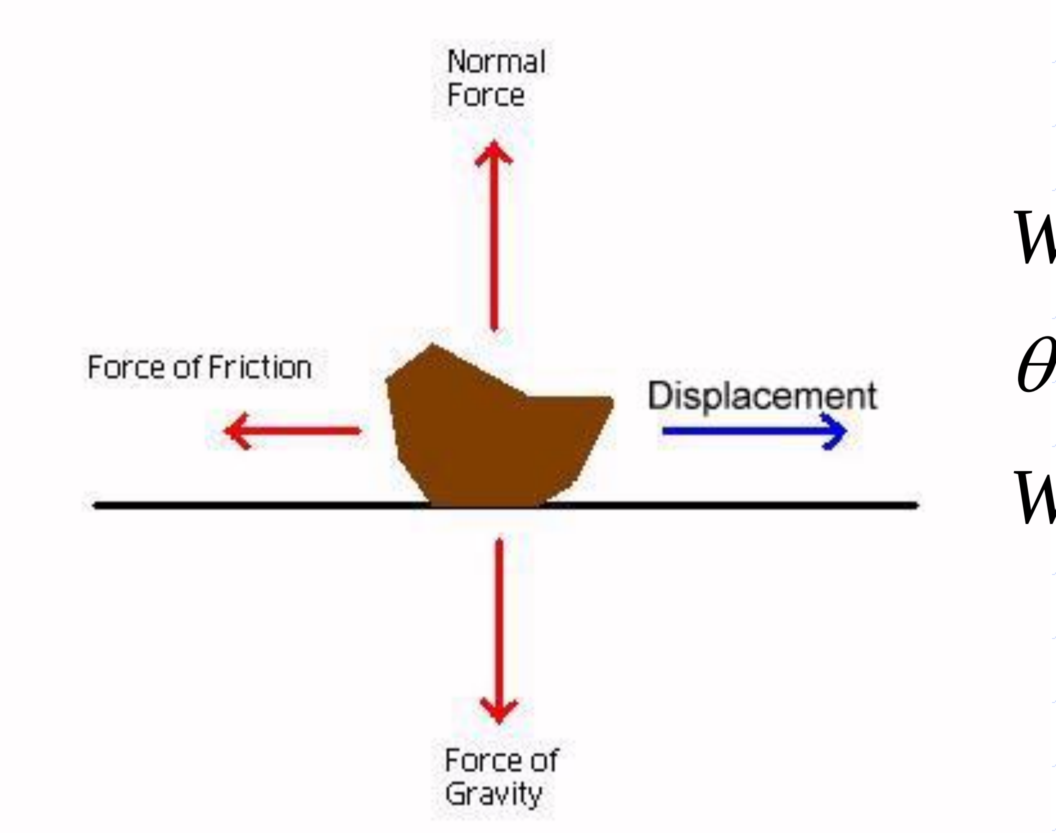
- Perpendicular components do no work.

Force and displacement are parallel



The cos of 0º is 1, so you can simply use the formula Work = F x d when the force and motion are in the same direction.

Force and motion are 180º

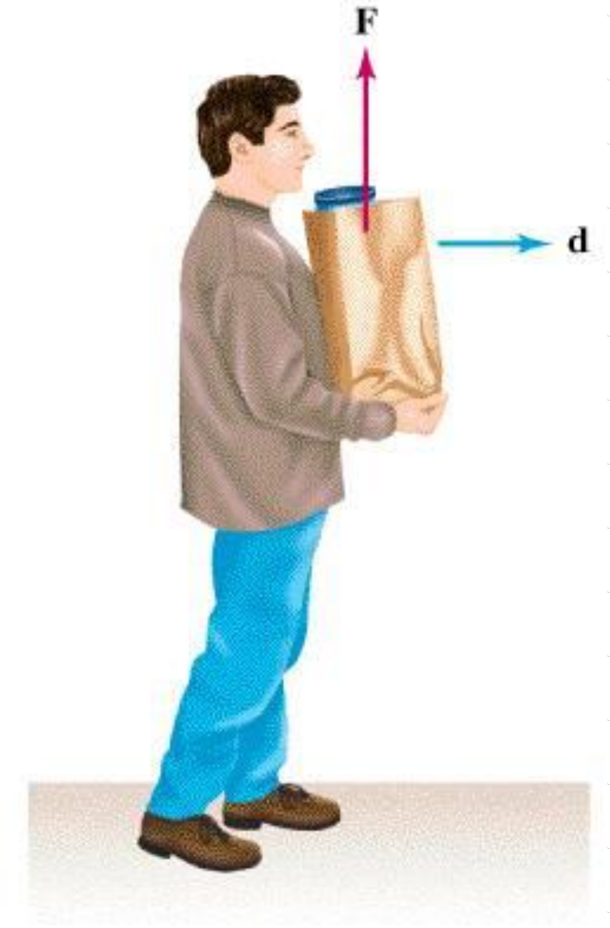


$$W = \vec{F} \bullet \Delta\vec{x} \rightarrow \vec{F}\vec{x}\cos\theta$$

$$\theta = 180^{\circ}; \cos 180 = -1$$

$$W = -\vec{F}_f\vec{x}$$

Force and motion at 90º

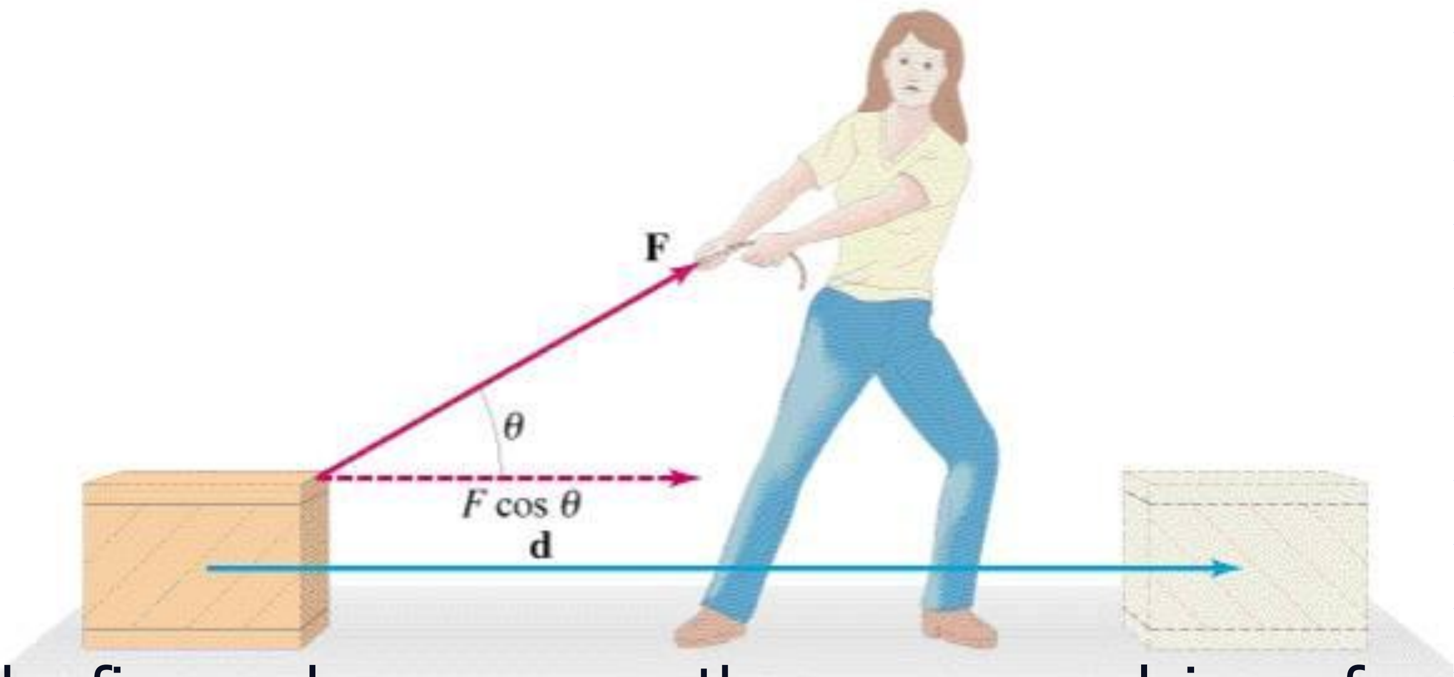


$$W = \vec{F} \bullet \Delta\vec{x} \rightarrow \vec{F}\vec{x}\cos\theta$$

$$\theta = 90^{\circ}; \cos 90 = 0$$

$$W = 0J$$

Force at an angle



In the figure above, we see the woman applying a force at an angle theta. Only the HORIZONTAL COMPONENT actually causes the box to move and thus imparts energy to the box. The vertical component (FsinΘ) does NO work on the box because it is NOT parallel to the displacement.

I. Work

How do we find the amount of work done when force is applied at an angle?

Find the component of force that is parallel to motion

I. Work

- If more than one force is acting on the object find the net force and then find the net work

(same direction add)

(opposite direction subtract)

Multiple Forces

- Draw a Free Body Diagram.
- Only components parallel to motion are needed.
- Solve for work done by individual forces or the net work.
- $W_{net} = F_{net} \times d$

I. Work

E. The SI unit is a Joule (J) which = 1 N*m

Work is a scalar so it has no direction; just magnitude.

I. Work

- Positive values indicate force is in same direction as motion. (working for; transferring energy to the object)

- Negative values indicate force is in opposite direction of motion (working against; transferring energy from the object)

I. Work

- Example:

A 10 kg wagon is pulled by an applied force of 100 N that is 25^o above the horizon for 5.0 m. A frictional force of 30 N acts the entire time. Find the work done by each force and the net work done on the wagon.

II. Work-Energy Theorem

- The net work done on an object is equal to the **change** in energy.

$$W_{net} = \Delta E$$

II. Work-Energy Theorem

- Kinetic energy is the energy associated with an object's motion and is defined as

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

II. Work – energy theorem

- All forces acting on the object must be considered to calculate the net work.

II. Work – energy Theorem

- An objects speed increases if the net work is positive.
  - $KE_f > KE_i$
- An object is slowing down if the net work is negative.
  - $KE_i > KE_f$

II. Work-energy Theorem

- A 10 kg object is pushed across a level surface by a force of 100 N. The coefficient of friction is 0.25. How fast is the box going after 5.0 m if it started at rest?

II. Work-energy theorem

- Some forces achieve work by changing the object's potential energy.
  - Ex: gravitational force, spring force
  - Potential energy exists between two objects.

II. Work – Energy Theorem

- Potential energy is often referred to as "stored" energy.
  - Really it's how much energy will be transferred within a system if you "allow" it to transfer.

II. Work-Energy Theorem

- Example: Gravitational potential energy exists between any two masses.
  - Let's use the earth and you. The amount of work (energy transfer) that Earth's gravitational force will do on you depends on your location relative to the Earth.
  - $PE_g = m\,g\,h$
  - Keep in mine gravitational force is vertical so it only changes vertical motion

II. Work-energy theorem

- Example: Consider a spring. You transfer energy (elastic potential energy) to the spring when you compress or stretch it. If you allow the spring to return to its equilibrium position it will transfer energy to any objects connected to the spring.
  - PEe = ½ kx^2 where k is the spring constant

    x is how far stretched or compressed

III. Power

- The rate at which work is done or the rate at which energy changes.
- $P = W/t$ or ….
- Units are Watts (W)
- 1 W is equal to 1 J/s