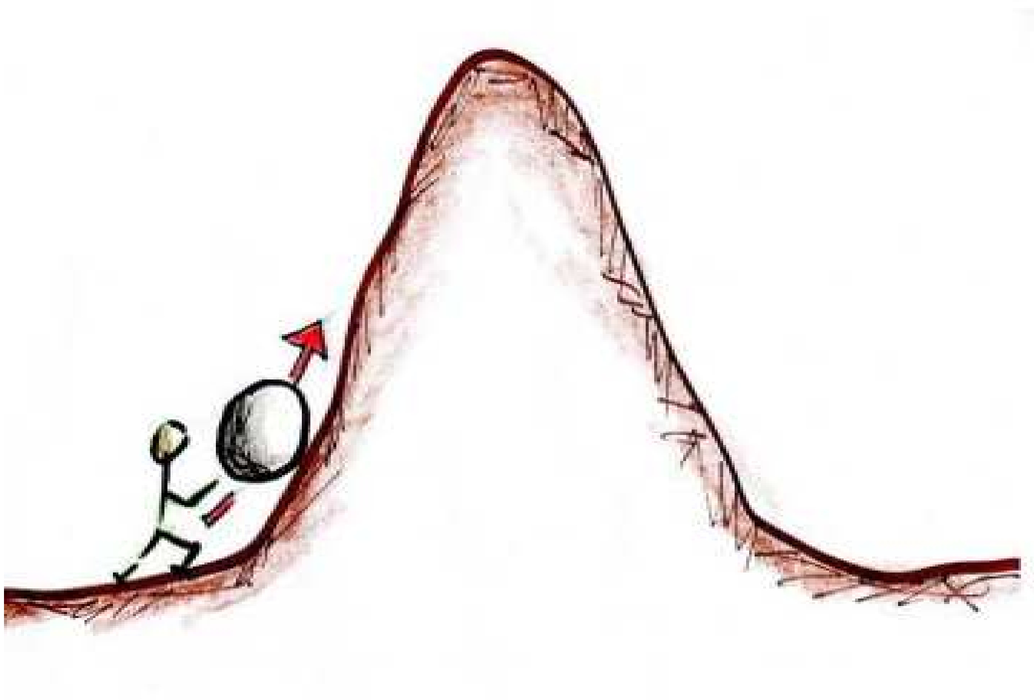
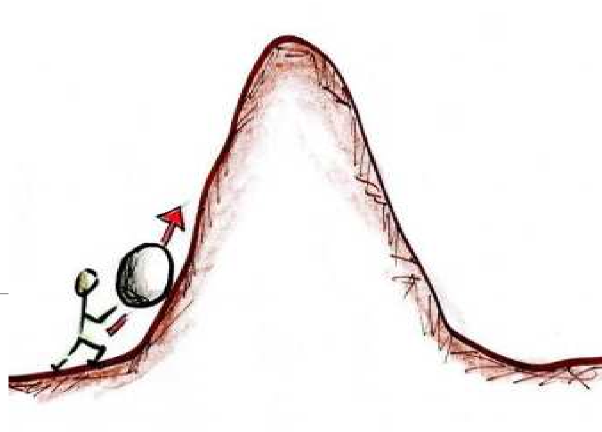
WORK, ENERGY AND POWER



WORK, ENERGY AND POWER



OBJECTIVES:

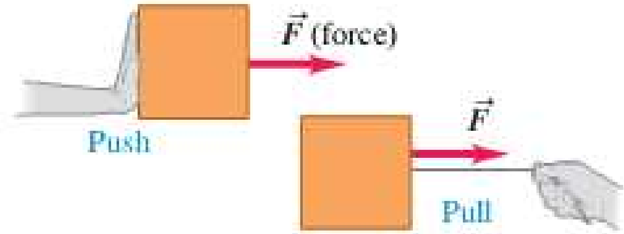
- What it means for force to do work on a body?
- How to calculate the amount of work done?
- What is kinetic energy and how is it calculated?
- What is the relationship between work and kinetic energy?
- Solving problems involving power!

QUICK REVIEW: NEWTON'S LAWS OF MOTION

<u>First Law</u>: A body acted on by no net force moves with constant velocity (which may be zero) and zero acceleration.

<u>Second Law</u>: If a net external force acts on a body, the body accelerates. The direction of acceleration is the same as the direction of the net force. The mass of the body times the acceleration of the body equals the net force vector.

<u>Third Law</u>: If body **A** exerts a force on body **B** (an "action"), then body **B** exerts a force on body **A** (a "reaction"). These two forces have the same magnitude but are opposite in direction. These two forces act on different bodies.



QUICK REVIEW: TYPES OF FORCE

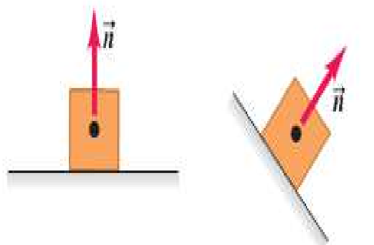
Force simply means a push or a pull!

Force is an interaction between two bodies or between a body and its environment.

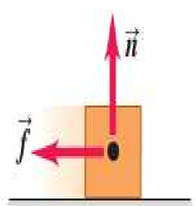
Force is a vector quantity.

Four types of forces: Normal Force, Frictional Force, Tension Force and Weight.

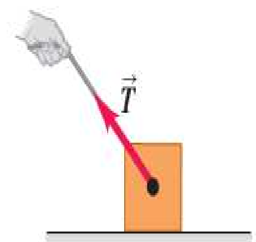
(a) **Normal force $\vec{n}$:** When an object rests or pushes on a surface, the surface exerts a push on it that is directed perpendicular to the surface.



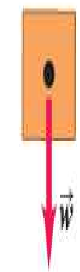
(b) **Friction force $\vec{f}$:** In addition to the normal force, a surface may exert a frictional force on an object, directed parallel to the surface.



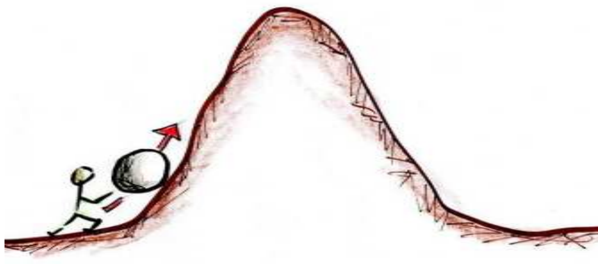
(c) **Tension force $\vec{T}$:** A pulling force exerted on an object by a rope, cord, etc.



(d) **Weight $\vec{w}$:** The pull of gravity on an object is a long-range force (a force that acts over a distance).



WORK



What is Work?

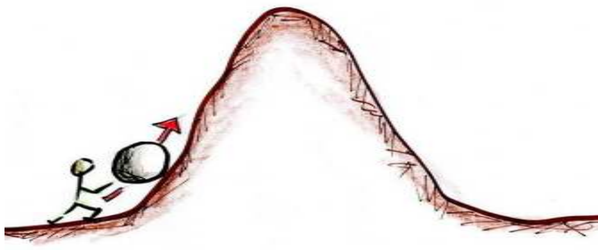
Ans: Work is said to be done on a body, when a force of magnitude **F** move the body through a displacement **x** which is in the direction of the force.

Work done by a constant force **F** is defined as the product of the magnitude of the force **F** and the displacement magnitude **x**.

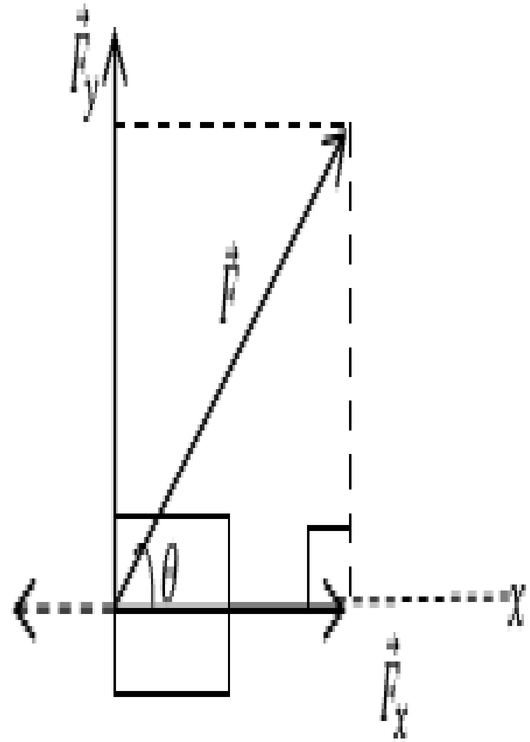
Where $\boldsymbol{W = Fx}$

The SI unit of work is the **joule** (J). By the definition of work,

1 Joule = (1newton)(1metre) or 1 J = 1 N.m



WORK



If the force is applied at an angle θ to the direction of the displacement as shown below.

Then F has a component $\boldsymbol{F_x}$ = **F**$\cos\theta$ acting parallel to the displacement and $\boldsymbol{F_y}$ = **F**$\sin\theta$ acting perpendicularly to the displacement.

Since work must be in the direction of the displacement, work in this case is defined by:

$$\boldsymbol{W = Fx\cos\theta}$$

When force and displacement are given in vector notation form ($\vec{F}$ and $\vec{x}$), work is expressed as:

$\boldsymbol{W = \vec{F}.\vec{x}}$ (Note this is a scalar/dot product)

WORK

Class Example

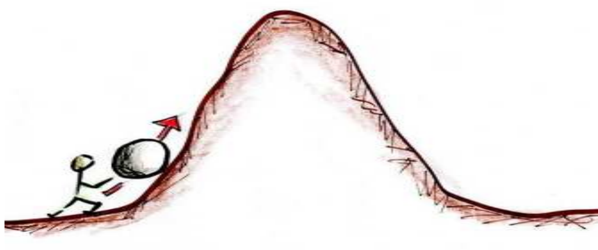
1) Kio Patrick applied a force of magnitude 205N to a stone and draged it at an angle of 30° to the direction of motion which is a distance of 10m.

a) How much work is done by the Patrick?

b) If Ose applies a force of $\vec{F} = (150N)\hat{\imath} - (30N)\hat{\jmath}$ to another stone and pull it through a displacement of $\vec{X} = (15m)\hat{\imath} + (12m)\hat{\jmath}$. How much work is done by Ose?

Answer: a) 1775.35 J b) 1890 J

WORK: Things to Note!



###: Work applied to a body may be <u>positive</u>, <u>negative</u> or <u>zero</u>.

1) It is positive if the force is in the same direction as the displacement.

2) It is negative if the displacement is in opposite direction to the force applied.

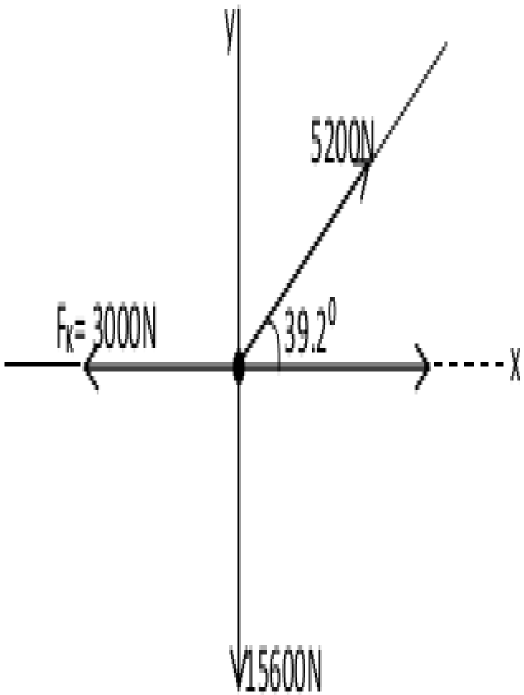
3) It is zero when there is no displacement even though force is applied or when the force is perpendicular to the displacement

WORK

Class Example:

2) A body of weight 15600N is being dragged at an angle 39.2° through the distance 23m along a surface with a constant force of 5200N. If the kinetic friction between the surface and the body is 3000N.

Find the total work on the body?



KINETIC ENERGY

Energy: the ability to do work (also measured in joules).

Kinetic energy is the energy that is associated with the speed of a body.

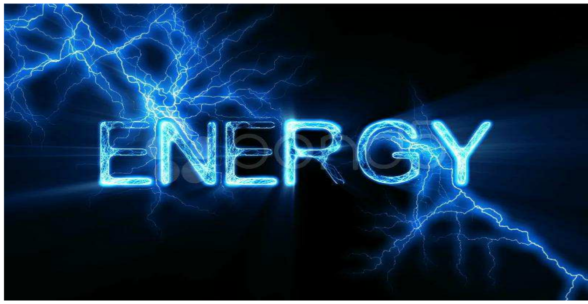
It is defined by: $K = \frac{1}{2}mv^2$

Kinetic energy is a scalar quantity.

The SI unit of kinetic energy is also joule (J). It has the same dimension as work.

1 J = 1 N.M

WORK- KINETIC ENERGY THEOREM



Just like work is related to the displacement of a body, work is also related to kinetic energy.

<u>Work-Energy Theorem</u>: It states that the work done by the net force on a particle equals the change in the particle's kinetic energy.

Where: $\boldsymbol{W_{total}} = \Delta \boldsymbol{K} = \boldsymbol{K_2} - \boldsymbol{K_1}$

K_1= initial kinetic energy

K_2= final kinetic energy

WORK- KINETIC ENERGY THEOREM

Class Example

3) The total work done on the particle of mass m = 1000kg to drag it through a particular distance is 11,000J. Suppose the initial speed of the particle is 2.0m/s.

What is the speed of the particle at the end of the distance?

Answer: 5.1m/s

POWER

Power: It is the rate at which work is done.

Power is also a scalar quantity.

When a quantity of work **ΔW** is done over a time interval **Δt**, the average power expended **P** is defined as:

$$P = \frac{\Delta W}{\Delta t}$$

Instantaneous power can be expressed as:

$$P = \lim_{\Delta t \to 0} \frac{\Delta W}{\Delta t} = \frac{dW}{dt}$$

The S.I unit of power is watt (W). 1 W = 1 J/s

POWER

Horsepower (hp): A larger unit of power.

1 hp = 746 W = 0.746 KW

The kilowatt-hour (KW.h) is a commercial unit of electrical energy.

One kilowatt-hour is equivalent to 1000 J of electrical energy expended in 1 hour (3600s).

i.e 1 KW.h = 3.6MJ

Power can also be expressed in terms of force and velocity. That is:

P = Fv

In vector notation form, power is expressed as the scalar product of force and velocity:

Where: $P = \vec{F}.\vec{v}$

POWER

#THURSDAYTRIVIA

1) How many joules of energy does a 150Watt light bulb use per hour?

2) With Q.1 above, How fast would a 80kg person have to run to have that amount of kinetic energy?

Answer: a) 540000 J b) 116.18 m/s

CLASS-PROBLEMS!= Everybody get your hands busy.

1) A constant force $\vec{F} = (25N)\hat{\imath} - (35N)\hat{\jmath}$ is applied horizontally to a load against a blowing wind. If the load undergoes a displacement of $\vec{s} = (-8.0m)\hat{\imath} - (3m)\hat{\jmath}$, how much work does the force applied do on the load?

2a) How many joules of kinetic energy does a runner of mass 75 kg travelling at a speed of 10 m/s have?

2b) By what factor would its kinetic energy decrease if he travels half as fast?

2c) How fast would he has to run to have half as much kinetic energy as in part (a)?

3) A towing vehicle pulls a car 6.00 km along a horizontal road way using a cable having a tension of 890 N. How much work does the cable do on the car if it pulls horizontally? If it pulls at 36.0° above the horizontal?

BIBLIOGRAPHY

1) Sears and Zemansky's University Physics with Modern Physics. 14th Edition: Hugh D. Young. Roger A. Freedman

2) Schaum's Outlines College Physics. 11th Edition: Eugene Hecht.

3) University Physics. Volume 1. Poh Liong Young, M.W. Anyakoha, P.N. Okeke

4) The Physics for University and Colleges. Volume 1. Kehinde Daniel and Opadele Abayomi

QUESTION TIME????????????????

About Lecturer:

Opadele A.E is a physics enthusiast with special interest in Medical Physics. He loves to present the complex theories in physics in seemingly simple approach for effectual understanding.

opadelea@babcock.edu.ng

abayomi_opadele

@abayomiopadele

Opadele Abayomi