Chapter 1

Mechanics

1- Physics and Measurements

We discover physics by learning how to measure the quantities involved in physics. Among these quantities are length, time, mass, temperature, pressure, Area, Density, power, and electric current……..

The three fundamental quantities are length, mass, and time. All other quantities (derived quantities) in mechanics can be expressed in terms of these three.

Systems of Units:

We measure each physical quantity in its own units; the unit is a unique name we assign to measures of that quantity.

There are many systems of units are used to measure the physical quantities as:

1- The British Engineering System or the (F. P. S. System):

Where the foot (ft) is the unit of the length, pound (lb) is the unit of the mass, and the second (sec) is the unit of the time.

2- The Gaussian System or the (c. g. s. System):

Where the centimeter (cm) is the unit of the length, gram (gm) is the unit of the mass, and the second (sec) is the unit of the time.

3- The Metric System or the (M. K. S. System):

Where the Meter (m) is the unit of the length, Kilogram (kg) is the unit of the mass, and the Second (sec) is the unit of the time.

4- The International System or the (S. I. System):

There are seven basic units, where the Meter (m) is the unit of the length, Kilogram (kg) is the unit of the mass, the Second (sec) is the unit of the time, kelvin (K) is the unit of the temperature, Ampere (A) is the unit of the electric current, candela is the unit of the intensity, and mole is the unit of the amount of substance.

	F. P. S. System	c. g. s. System	M. K. S. System	S. I. System
Length	Foot (ft)	centimeter(cm)	Meter (m)	Meter (m)
Mass	pound (lb)	gram (gm)	Kilogram (kg)	Kilogram (kg)
Time	Second (sec)	Second (sec)	Second (sec)	Second (sec)

Note that:

1 ft = 30.48 cm = 0.3048 m

1 lb = 453.6 gm = 0.4536 kg

Derived quantities

All physical quantities measured by physicists can be expressed in terms of the three basic unit of length, mass, and time. For example, speed, Density, Force, Power, and Pressure……..

Complete the following Table:

Quantity	Law	Unit		
		In F.P.S.	In c. g. s.	In S.I.
Length				
Mass				
Time				
Area	$(\text{Distance})^2$			
Volume	$(\text{Distance})^3$			
Density	$\frac{Mass}{Volume}$			
Velocity	$\frac{Distance}{Time}$			
Acceleration	$\frac{Velocity}{Time}$			
Force	Mass x Acc.			
Work	Force x Distance			
Pressure	$\frac{Force}{Area}$			
Momentum	Mass x Velocity			
Energy	$\text{Mass x } (\text{Velocity})^2$			
Power	$\frac{Energy}{Time}$			

2- Vectors

A particle moving along a straight line can move in only two directions. We can take its motion to be positive in one of these directions and negative in the other. For a particle moving in three dimensions, however, a plus sign or minus sign is no longer enough to indicate a direction. Instead, we must use a vector.

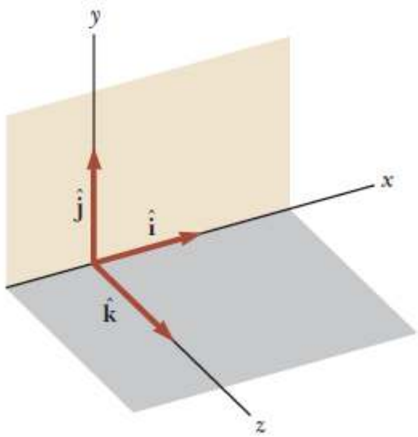
A vector has magnitude as well as direction. **A vector quantity** is **a quantity that has both a magnitude and a direction** and thus can be represented with a vector. Some examples for the physical quantities that we can term it as vector quantities are displacement, velocity, and acceleration.

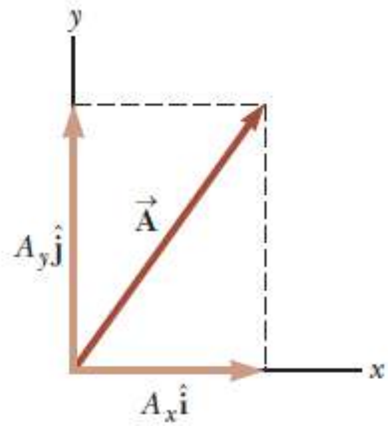
Not all physical quantities involve a direction. For example, Temperature, pressure, energy, mass, and time, we call such quantities as **scalar quantity** which is **a quantity that has only magnitude.**

In general, vectors are represented by putting an arrow over the physical quantity to indicate that it has both properties of a vector, magnitude and direction.

Unit vectors

A unit vector is **a vector that has a magnitude of exactly one and points in a particular direction**. The unit vectors in the positive directions of the x, y, and z axes are labeled $\hat{\imath}$, $\hat{\jmath}$, and , $\hat{k}$ where the hat is used instead of an overhead arrow as for other vectors.





Unit vectors are very useful for expressing other vectors; for example, consider a vector $\vec{A}$ lying in the xy plane as shown in the above Figure, Therefore, the unit-vector notation for the vector $\vec{A}$ is:

$$\vec{A} = A_x\,\hat{\imath} + A_y\,\hat{\jmath}$$

Which mean that, the vector $\vec{A}$ has a magnitude A_x in the X direction and magnitude A_y in the y direction.

Adding Vectors by Components

Consider the statement:

$$\vec{r} = \vec{a} + \vec{b}$$

which says that the vector $\vec{r}$ is the same as the vector $(\vec{a} + \vec{b})$. Thus, each component of $\vec{r}$ must be the same as the corresponding component of $(\vec{a} + \vec{b})$.

For example, if a,b and r in the xy plane only, so

$$r_x = a_x + b_x$$

$$r_y = a_y + b_y$$

To add vectors $\vec{a}$ and, $\vec{b}$ we must:

(1) Resolve the vectors into their scalar components;

(2) Combine these scalar components, axis by axis, to get the components of the sum $\vec{r}$; and

(3) Combine the components $\vec{r}$ of to get $\vec{r}$ itself. We have a choice in step 3. We can express in **unit-vector notation** as:

$$\vec{r} = r_x\,\hat{\imath} + r_y\,\hat{\jmath}$$

Or in **magnitude-angle notation** as:

$$\vec{r} = r \angle \theta$$

where the magnitude r of the vector $\vec{r}$ is given by: $r = \sqrt{r_x{}^2 + r_y{}^2}$

while the angle θ that $\vec{r}$ makes with the x direction is given by :

$$\theta = \tan^{-1}\left(\frac{r_y}{r_x}\right)$$

At times, we need to consider situations involving motion in three component directions. If $\vec{A}$ and $\vec{B}$ both have x, y, and z components, they can be expressed in the form:

$$\vec{A} = A_x\,\hat{\imath} + A_y\,\hat{\jmath} + A_z\,\hat{k}$$

$$\vec{B} = B_x\,\hat{\imath} + B_y\,\hat{\jmath} + B_z\,\hat{k}$$

The sum of $\vec{A}$ and $\vec{B}$ in the unit-vector notation is:

$$\vec{R} = (A_x + B_x)\,\hat{\imath} + (A_y + B_y)\hat{\jmath} + (A\_z + B\_z)\,\hat{k}$$

And in **magnitude-angle notation:**

$$R = \sqrt{{R_x}^2 + {R_y}^2 + {R_z}^2}$$

The angle θ_x that $\vec{R}$ makes with the x axis is found from the expression $\cos\theta_x = R_x/R$, with similar expressions for the angles with respect to the y and z axes.

$\cos\theta_y = R_y/R$ $\cos\theta_z = R_z/R$

Example (1):

Two displacement vectors $\vec{A}$ and $\vec{B}$ lying in the xy plane and given by: $\vec{A} = 2\,\hat{\imath} + 2\,\hat{\jmath}\ m\ and\ \vec{B} = 2\,\hat{\imath} - 4\,\hat{\jmath}\ m$

Find $\overrightarrow{R}$, the sum of them, in **unit-vector notation** and in **magnitude-angle notation**

Solution:

Example (2):

A particle undergoes three consecutive displacements:

$\vec{A} = (15\,\hat{i} + 30\,\hat{j} + 12\,\hat{k})\ cm$, $\vec{B} = \left(23\,\hat{i} - 14\,\hat{j} - 5\,\hat{k}\right)\ cm$, and

$\vec{C} = (-13\,\hat{i} + 15\,\hat{j}\,)cm$. Find **unit-vector notation** for the resultant displacement and **its magnitude-angle notation**.

Solution:

Multiplying Vectors

There are two ways in which vectors can be multiplied,

The scalar product:

The scalar product of the vectors $\vec{a}$ and $\vec{b}$ is written as ($\vec{a}\,.\,\vec{b}$) and defined to be:

$$\vec{a}\,.\,\vec{b} = \mathrm{a\,b\cos\theta}$$

where a is the magnitude of $\vec{a}$, b is the magnitude of $\vec{b}$, and θ is the angle between $\vec{a}$ and $\vec{b}$.

When two vectors are in unit-vector notation, we write their dot product as:

$$\vec{a}\,.\,\vec{b} = (a_x\,\hat{\imath} + a_y\,\hat{\jmath} + a_z\,\hat{k})\,.\,(b_x\,\hat{\imath} + b_y\,\hat{\jmath} + b_z\,\hat{k})$$

Note that:

For the unit vectors:

The multiple of similar unit vectors = 1 where,

$$\hat{\imath}\,.\,\hat{\imath} = \hat{\jmath}\,.\,\hat{\jmath} = \hat{k}\,.\,\hat{k} = 1 \times 1\cos 0 = 1 \times 1 \times 1 = 1$$

While any other multiple for different unit vectors = 0 where,

$$\hat{\imath}\,.\,\hat{\jmath} = \hat{\imath}\,.\,\hat{k} = \hat{\jmath}\,.\,\hat{\imath} = \hat{\jmath}\,.\,\hat{k} = \hat{k}\,.\,\hat{\imath} = \hat{k}\,.\,\hat{\jmath} = 1 \times 1\cos 90 = 1 \times 1 \times 0 = 0$$

So,

$$\vec{a}\,.\,\vec{b} = a_x b_x + a_y b_y + a_z b_z$$

The vector product:

The vector product of the vectors $\vec{a}$ and $\vec{b}$ is written as ($\vec{a} \times \vec{b}$) and defined to be:

$$\vec{a} \times \vec{b} = a\, b \sin\theta \,.\, \hat{n}$$

where a is the magnitude of $\vec{a}$, b is the magnitude of $\vec{b}$, θ is the angle between $\vec{a}$ and $\vec{b}$, and $\hat{n}$ is the unit vector of the new result vector.

When two vectors are in unit-vector notation, we write their dot product as:

$$\vec{a} \times \vec{b} = (a_x\,\hat{\imath} + a_y\,\hat{\jmath} + a_z\,\hat{k}) \times (b_x\,\hat{\imath} + b_y\,\hat{\jmath} + b_z\,\hat{k})$$

Note that:

For the unit vectors:

The multiple of similar unit vectors = 0 where,

$$\hat{\imath} \times \hat{\imath} = \hat{\jmath} \times \hat{\jmath} = \hat{k} \times \hat{k} = 1 \times 1 \sin 0 = 1 \times 1 \times 0 = 0$$

While any other multiple for different unit vectors given by:

$$\hat{\imath} \times \hat{\jmath} = \hat{k}\,, \qquad \hat{\jmath} \times \hat{k} = \hat{\imath}, \qquad \hat{k} \times \hat{\imath} = \hat{\jmath}\,,$$

$$\hat{\jmath} \times \hat{\imath} = -\hat{k}, \qquad \hat{k} \times \hat{\jmath} = -\hat{\imath}, \qquad and\ \hat{\imath} \times \hat{k} = -\hat{\jmath}$$

So,

$$\vec{a} \times \vec{b} = (a_y b_z - b_y a_z)\hat{\imath} + (a_z b_x - b_z a_x)\hat{\jmath} + (a_x b_y - b_x a_y)\hat{k}$$

Example (3):

If $\vec{A} = (3\,\hat{\imath} - 4\,\hat{\jmath})$ and $\vec{B} = (-2\,\hat{\imath} + 3\,\hat{k})$. Find

(1) $\vec{A} + \vec{B}$ (2) $\vec{A} \cdot \vec{B}$ and (3) $\vec{A} \times \vec{B}$

Solution:

Example (4):

If $\vec{A} = (3\,\hat{\imath} - 2\,\hat{\jmath} + 4\hat{k})$ and $\vec{B} = (-5\,\hat{\imath} + 2\hat{\jmath} - \hat{k})$. Find

(1) $\vec{A} + \vec{B}$ (2) $\vec{A} \cdot \vec{B}$ and (3) $\vec{A} \times \vec{B}$

Solution:

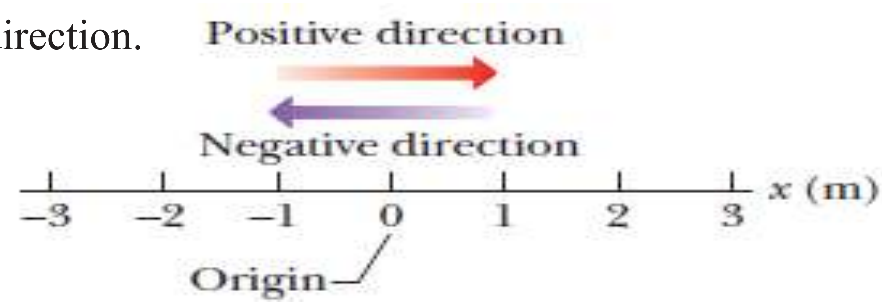
3- Motion along a straight line:

In this chapter, we study the basic physics of motion where the object (race car, tectonic plate, blood cell, or any other object) moves along a single axis. Such motion is called one-dimensional motion.

From everyday experience, we recognize that motion of an object represents a continuous change in the object's position. In physics, we can categorize motion into three types: translational, rotational, and vibrational. A car traveling on a highway is an example of translational motion, the Earth's spin on its axis is an example of rotational motion, and the back and- forth movement of a pendulum is an example of vibrational motion. Now, we will concern only with translational motion.

Position and Displacement

A particle's **position** x is the location of the particle with respect to a chosen reference point that we can consider to be the origin of an axis such as the x axis in the Fig. The positive direction of the axis is in the direction of increasing numbers (coordinates), which is to the right. The opposite is the negative direction.



For example, a particle might be located at x =5 m, which means it is 5 m in the positive direction from the origin. If it were at x = -5 m, it would be just as far from the origin but in the opposite direction. A plus sign for a coordinate need not be shown, but a minus sign must always be shown.

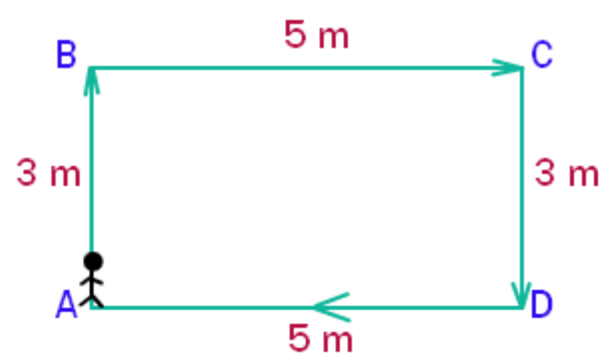
The **displacement** Δx of a particle is defined as **its change in position in some time interval.** As the particle moves from an initial position x_i to a final position x_f , its displacement is given by:

$$\Delta x = x_f - x_i$$

We see that Δx is positive if x_f is greater than x_i and negative if x_f is less than x_i.

It is very important to recognize the difference between **displacement and distance** traveled. **Distance is the length of a path followed by a particle**.

Consider, for example, if a person moves from point A to B to C to D then return to A as the shown Fig., the displacement of this person during this time interval is zero because he ended up at the same point as he started : $x_f = x_i$, so Δx = 0. During this time interval, however, he moved through a distance = 16 m.



Displacement at point A = 0
Distance traveled at point A = 16 m

Distance is always represented as a positive number, whereas displacement can be either positive or negative.

Average velocity and Average speed

The average velocity v_{avg} of a particle is defined as **the particle's displacement Δx divided by the time interval Δt during which that displacement occurs**:

$$v_{avg} = \frac{\Delta x}{\Delta t}$$

The average velocity of a particle moving in one dimension can be positive or negative, depending on the sign of the displacement. (The time interval Δt is always positive).

Average speed s_{avg}, is defined as **the total distance d traveled divided by the total time interval required to travel that distance**:

$$S_{avg} = \frac{d}{\Delta t}$$

Unlike average velocity, average speed has no direction and is always expressed as a positive number.

Instantaneous velocity, It is the velocity at any instant

Acceleration:

When a particle's velocity changes with time, the particle is said to undergo acceleration (or to accelerate). For motion along an axis, the average acceleration a_{avg} over a time interval Δt is:

$$a_{avg} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

where the particle has velocity v_1 at time t_1 and then velocity v_2 at time t_2.

Instantaneous acceleration:

Constant Acceleration

In many types of motion, the acceleration is either constant or approximately so. This is a special case, so we can generate several equations that describe the motion of a particle for this case: as the following:

When the acceleration is constant, the average acceleration and instantaneous acceleration are equal and we can write:

$$a = a_{avg} = \frac{v - v_o}{t - 0}$$

Here v_o (the initial velocity) is the velocity at time $t = 0$ and v (the final velocity) is the velocity at any later time t. We can recast this equation as:

$$v = v_o + at \qquad \textit{the first eq.}$$

And for the velocity we can write:

$$v_{avg} = \frac{x - x_o}{t - 0}$$

So, $$x - x_o = v_{avg}\, t$$

Due to the average velocity can be given by:

$$v_{avg} = \frac{1}{2}(v + v_o) = \frac{1}{2}(2v_o + at) = v_o + \frac{1}{2}at$$

So, $$x - x_o = \left(v_o + \frac{1}{2}at\right) t$$

$$\therefore x - x_o = v_o t + \frac{1}{2}at^2 \qquad \textit{the second eq.}$$

From the first and second equation we can get:

$$v^2 = {v_o}^2 + 2a(x - x_o) \qquad \textit{the third eq.}$$

Example (5):

An object moving with uniform acceleration has a velocity of 12 m/s in the positive x direction when its x-coordinate is 3.00 m. If its x-coordinate after 2.00 s later is –5.00 m, what is its acceleration?

Solution:

At $x_o = 3$ m, $v_o = 12$ m/s, and at time t = 2 sec, x = -5m, So

$$x - x_o = v_o t + \frac{1}{2}at^2$$

$$\therefore -5 - 3 = 12 \times 2 + \frac{1}{2}a(2)^2 \qquad \Rightarrow \qquad \therefore a = -16\, m/sec^2$$

Example (6) :

A jet plane lands with a speed of 100 m/s and can accelerate at a maximum rate of –5.00 m/s^2 as it comes to rest. (a) From the instant the plane touches the runway, what is the minimum time interval needed before it can come to rest? (b) Can this plane land on a small tropical island airport where the runway is 0.800 km long?

Solution:

(a) $v_o = 100$ m /s , v = 0 m /s, $x_o = 0$, and a = −5 m /s^2,

$$v = v_o - at$$

$$\therefore 0 = 100 - 5t \qquad \Rightarrow \qquad \therefore t = 20 \text{ sec}$$

(b) $x - x_o = v_o t - \frac{1}{2} a t^2$

$$\therefore x - 0 = 100 \times 20 - \frac{1}{2} 5 \times (20)^2 \qquad \Rightarrow \quad \therefore x = 1000\, m$$

So, the plane cannot land on that small airport, where at this acceleration the plane would overshoot the runway.

4- Force and Laws of Motion

In the previous topic, we described the motion of an object in terms of its position, velocity, and acceleration without considering what might influence that motion.

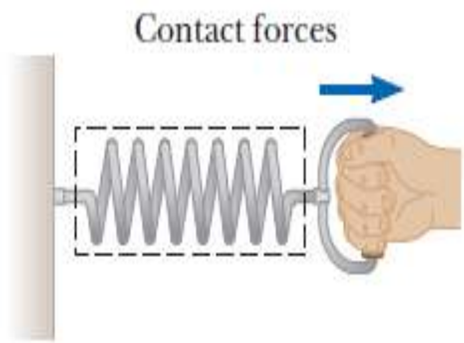
Now we consider that influence: Why does the motion of an object change? What might cause one object to remain at rest and another object to accelerate? Why is it generally easier to move a small object than a large object? The two main factors we need to consider are the forces acting on an object and the mass of the object.

The Concept of Force

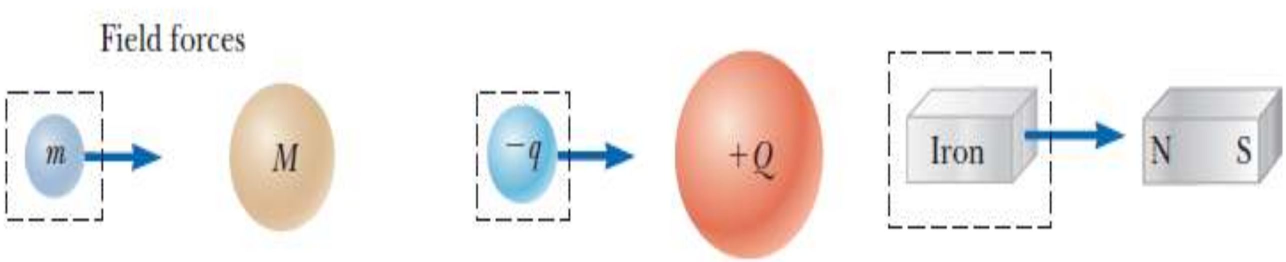
Everyone has a basic understanding of the concept of force from everyday experience. When you push your empty dinner plate away, you exert a force on it. Similarly, you exert a force on a ball when you throw or kick it. In these examples, the word force refers to an interaction with an object by means of muscular activity and some change in the object's velocity. Forces do not always cause motion, however. For example, when you are sitting, a gravitational force acts on your body and yet you remain stationary. As a second example, you can push (in other words, exert a force) on a large boulder and not be able to move it.

Force can be classified into two classes:

Contact forces: which involve physical contact between two objects. For examples, when a coiled spring is pulled, when a football is kicked and the force exerted by your feet on the floor.



Field forces: where it does not involve physical contact between two objects. These forces act through empty space. For examples, the gravitational force of attraction between two objects with mass, the electric force that one electric charge exerts on another, and the force a bar magnet exerts on a piece of iron.



Mass

Mass is that property of an object that specifies how much resistance an object exhibits to changes in its velocity. Experiments show that the greater the mass of an object, the less that object accelerates under the action of a given applied force.

Mass should not be confused with weight. Mass and weight are two different quantities. The weight of an object is equal to the magnitude of the gravitational force exerted on the object and varies with location. For example, a person weighing 90kg on the Earth weighs only about 15kg on the Moon, while, its mass is the same.

Newton's first law of motion

If you send a puck sliding across a wooden floor, it does indeed slow and then stop. If you want to make it move across the floor with constant velocity, you have to continuously pull or push it. Send a puck sliding over the ice of a skating rink, however, and it goes a lot farther. You can imagine longer and more slippery surfaces, over which the puck would slide farther and farther. In the limit you can think of a long, extremely slippery surface (said to be a frictionless surface), over which the puck would hardly slow.

From these observations, we can conclude that a body will keep moving with constant velocity if no force acts on it. That leads us to the first of Newton's three laws of motion:

In the absence of external forces, an object at rest remains at rest and an object in motion continue in motion with a constant velocity.

In other words, when no force acts on an object, the acceleration of the object is zero. From the first law, we conclude that any isolated object (one that does not interact with its environment) is either at rest or moving with constant velocity. The tendency of an object to resist any attempt to change its velocity is called **inertia.**

Newton's second law of motion

Newton's first law explains what happens to an object when no forces act on it: it either remains at rest or moves in a straight line with constant speed. Newton's second law answers the question of what happens to an object when one or more forces act on it.

Imagine performing an experiment in which you push a block of mass **m** across a frictionless, horizontal surface. When you exert some horizontal force $\vec{F}$ on the block, it moves with some acceleration $\vec{a}$. If you apply a force twice as great on the same block, experimental results show that the acceleration of the block doubles; if you increase the applied force to $3\vec{F}$, the acceleration triples; and so on. From such observations, we conclude that the acceleration of an object is directly proportional to the force acting on it. $\vec{a} \propto \vec{F}$

And due to the magnitude of the acceleration of an object is inversely proportional to its mass: $|\vec{a}| \propto \frac{1}{m}$

So, Newton's second law can be summarized as:

The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass: $|\vec{a}| \propto \frac{\sum \vec{F}}{m}$

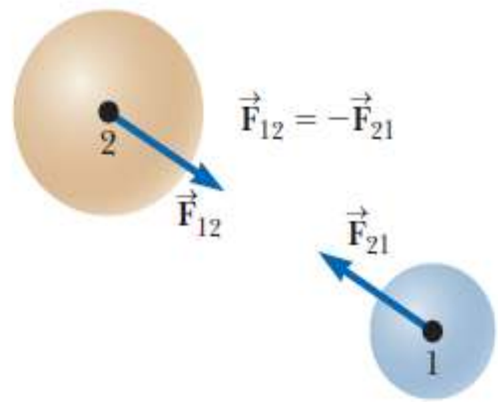
So, $\sum \vec{F} = m\,\vec{a}$ Where, $\sum \vec{\mathrm{F}}$ is the vector sum of all forces (net force) acting on the object.

Newton's Third Law of motion

Newton's third law states that:

When two bodies interact, the forces on the bodies from each other are always equal in magnitude and opposite in direction.

The force $\overrightarrow{F_{12}}$ exerted by object 1 on object 2 (called the action force) is equal in magnitude and opposite in direction to the force $\overrightarrow{F_{21}}$ exerted by object 2 on object 1(called the reaction force).



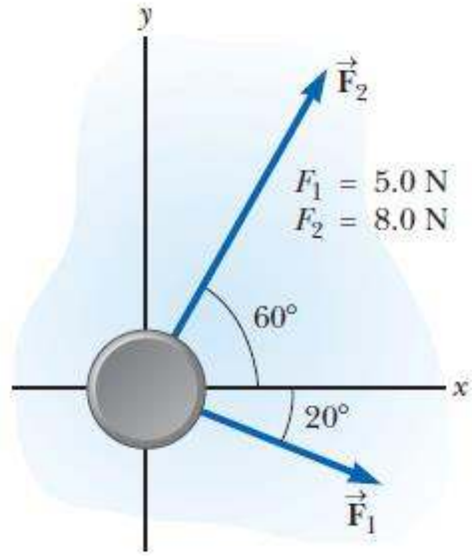
Example (7)

You push an object, initially at rest, across a frictionless floor with a constant force for a time interval Δt, resulting in a final speed of v for the object. You then repeat the experiment, but with a force that is twice as large. What time interval is now required to reach the same final speed v?

Solution

Example (8)

A hockey puck having a mass of 0.3 kg slides on the frictionless, horizontal surface of an ice rink. Two hockey sticks strike the puck simultaneously, exerting the forces on the puck as shown. The force $\overrightarrow{F_1}$ has a magnitude of 5 N, and the force $\overrightarrow{F_2}$ has a magnitude of 8 N. determine both the magnitude and the direction of the puck's acceleration.



Solution

Example (9)

Find the force (in magnitude – angle form) affected on an object of mass 5kg if its acceleration is given by $\vec{a}$ = 3i -4j

Solution

Example (10)

The same force is applied into two masses the first is accelerated by 0.5m/sec^2 while the other is accelerated by 5m/sec^2.

(a) Find the ratio between the two masses.

(b) Find the acceleration if the two masses are combined together and affected by the same force.

Solution

Example (11)

An object of mass 2 kg is observed to have acceleration with a magnitude of 10 m/s^2 in a direction 60° with the y- direction. Find the force acting on the object in the unit vector form.

Solution

5- Work and Energy

Work and energy are the same thing. When a force moves something along any distance we say that work has been done and energy has been transformed.

Work

When an object moves while a force is being exerted on it, then work is being done on the object by the force. If an object moves through a displacement **d** while a constant force **F** is acting on it, the force does an amount of work equal to:

$$W = F.d = Fd\cos\theta$$

where θ is the angle between **d** and **F**.

Work is also a scalar and has units of **1N · m = Joule**.

Work can be **negative**; this happens when the angle between force and displacement **is larger than 90°**. It can also be **zero**; this happens if **θ** = **90°**. So, to do work, the force must have a component along (or opposite to) the direction of the motion.

If several different (constant) forces act on a mass while it moves though a displacement **d**, then we can talk about **the net work** done by the forces:

$$W_{net} = F_1.d + F_2.d + F_3.d + F_4.d + \cdots$$

$$W_{net} = (\sum F).d$$

$$= F_{net}.d$$

Example 12:

A particle moving in the xy plane undergoes a displacement, given by $\vec{d} = (4\,\hat{\imath} - 3\,\hat{\jmath})$ m, when a constant force $\vec{F} = (2\,\hat{\imath} + 5\,\hat{\jmath})$ N acts on it. Calculate the work done by $\vec{F}$ on the particle.

Solution:

Example 13:

A 2 kg block initially at rest is pulled horizontally by a constant force of 24 N. Find the work done by the force after 5 second.

Solution:

Energy

A body which has the capacity to do work is said to possess energy. It means that the energy is **the ability of doing work or cause a change.** Energy produced by burning fuel inside the car engine makes the car able to move; also energy produced from food enables man to perform his activities and to do work. The SI units are the same as those for work, **Joules** J

There are many forms of energy for examples: Light, electrical, mechanical, chemical, nuclear, sound and thermal energy.

Mechanical energy as example for the types of energy is **the sum of both kinetic energy and potential energy.**

Kinetic energy

It is the work done during the motion of an object. For an object with mass **m** and speed **v**, the kinetic energy is given by:

$$K.E = \frac{1}{2} m v^2$$

And when a particle moves from point r_i to r_f, the change in kinetic energy of the object is equal to the net work done on it:

$$\Delta K = K_f - K_i = W_{net}$$

Potential energy

It is the energy stored in the object due to a work done on it. For an object with mass **m** and at height **h** from the earth surface with gravity acceleration **g**, the potential energy is given by:

$$P.E = m\,g\,h$$

The Total mechanical energy is given by:

$$E = K.E + P.E = W$$

Example 14:

A ball was launched upwards and vertically at a speed 3 m/s up to a height 4 m. What the work done on the ball if its weight is 5 Newton, and has a mass 0.5 Kg

Solution

Power

In certain applications we are interested in the rate at which work is done by a force. If an amount of work **W** is done in a time **Δt**, then we say that the average power **P** due to the force is:

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

The unit of power is the watt, Joule /sec or $kg.m^2/sec^3$

Example 15:

A constant force of 2kN pulls a crate along a level floor and accelerates it from rest to 10 m/sec in 5 sec. What is the power used?

Solution