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DEPARTMENT OF EDUCATION (S)
Government of Manipur

CHAPTER 8
DYNAMICS

NOTES
KEYNOTES 8.1

1. **Dynamics** is the science of moving bodies which is studied under two heads viz. kinematics and kinetics.

2. **Kinematics** deals with the geometrical aspect of the motion of a body for which entities like mass of the body are irrelevant.

3. **Kinetics** deals with the physical aspect of the motion of a body where mass of the body is indispensable.

4. **The displacement** of a moving particle in any time interval is its change of position during the interval of time.

5. **The velocity** of a moving particle is the rate of its displacement. It is uniform when it always moves along the same straight line in the same sense (i.e. in the same direction) and passes over equal distances in equal intervals of time.

6. **Acceleration** of a moving particle is the rate of change of its velocity. It is uniform when equal change of velocity in the same direction takes in equal interval of time.

7. A negative acceleration is known as **retardation.**

8. **Units of motion:**

   i) Velocity

   ft/sec in FPS system
   m/sec in MKS system
   cm/sec in CGS system

   ii) Acceleration

   ft/sec^2 in FPS system
   m/sec^2 in MKS system
   cm/sec^2 in CGS system

9. For a uniform velocity (v) acquired by a particle, the distance (s) described in t units of time is given by $s = vt$.

10. For a uniformly accelerated motion of a particle, we have

a) $v = u + ft$

b) $s = ut + \frac{1}{2} ft^2$

c) $v^2 = u^2 + 2fs$

d) The distance described by a particle in the nth second of its motion is given by

$$s_n = u + \frac{1}{2} f(2n-1)$$

KEYNOTES 8.2

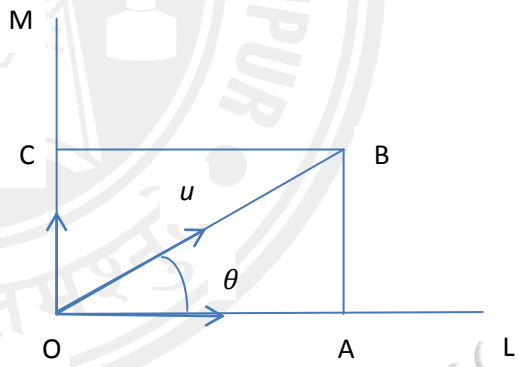
1. **Simultaneous velocities** - A body may have more than one velocity at a time. These velocities are called simultaneous velocities.

2. **Parallelogram law of velocities** - If a body possesses two simultaneous velocities which can be represented in magnitude and direction by two adjacent sides of a parallelogram drawn from one of its angular points, then their resultant is represented in magnitude and direction by the diagonal of the parallelogram drawn from the angular point.

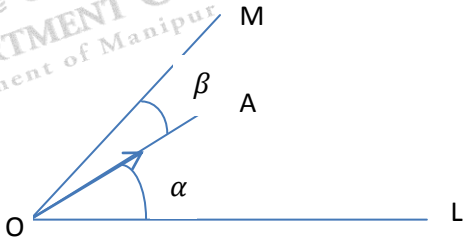
3. **Resolution of Velocities** – The process of splitting a given velocity into mutually perpendicular components is called resolution of the velocity.

Notes:

1) The components of u along two mutually perpendicular OL and OM are $u.cos\theta$ and $u.sin\theta$ respectively. These mutually perpendicular components of the velocity are called the resolved parts or the resolute along these direction.

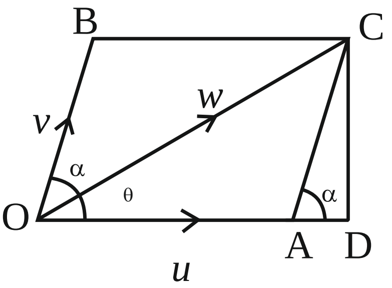


2) Let OL and OM be two arbitrary directions making angles α and β respectively with u .Then the components of u along OL and OM are $\frac{u.\sin\beta}{\sin(\alpha+\beta)}$ and $\frac{u.\sin\alpha}{\sin(\alpha+\beta)}$ respectively.



4. **Resultant velocity:** The single velocity which is equivalent to two or more velocities is called their resultant velocity.

5. **Resultant of two velocities:** If $\overrightarrow{OA}$ and $\overrightarrow{OB}$ represent the velocities u and v so that $\angle AOB = \alpha$. Completing the parallelogram *OACB*, then the diagonal $\overrightarrow{OC}$ represents the resultant velocity *w* of *u* and *v*. Thus, $w^2 = u^2 + v^2 + 2uv\cos\alpha$ which gives the magnitude of the resultant velocity and if θ is the angle between u and w, then $\tan\theta = \dfrac{v\sin\alpha}{u + v\cos\alpha}$ which gives the direction of the resultant velocity.



Corollary:

i) If *u* and *v* are perpendicular (i.e. $\alpha = 90^0$),, then $w^2 = u^2 + v^2$ and $\tan\theta = \dfrac{v}{u}$.

ii) If u and v have the same direction (i.e. $\alpha = 0$), then $w = u + v$ and direction of the resultant velocity is along the common direction(i.e. $\theta = 0$).

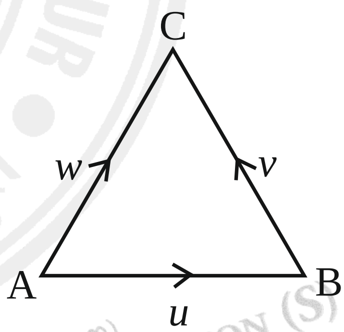
iii) If *u* and *v* have the opposite direction (i.e. $\alpha = 180^0$), then $w = |u - v|$ and direction of the resultant velocity is along *u* or *v* according as $u > v$ or $v > u$.

6. **Triangle law of velocities**

If a body has two simultaneous velocities u and v which can respectively represented in magnitude and direction by the sides *AB* and *BC* of a triangle *ABC*, then their resultant is represented by the third side *AC* in magnitude and direction.

Thus, $\overrightarrow{AB} + \overrightarrow{BC} = \overrightarrow{AC}$

$\Rightarrow \vec{u} + \vec{v} = \vec{w}$



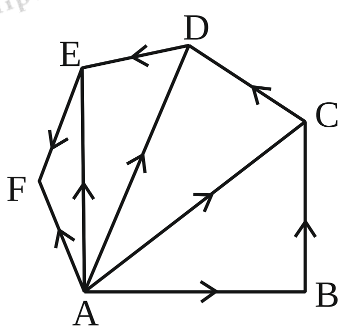
Or,

If a body has three simultaneous velocities which can be represented in magnitude and direction by the three sides of a triangle taken in order, then the resultant velocity is zero thereby keeping the body at rest.

7. **Polygon of Velocities:**

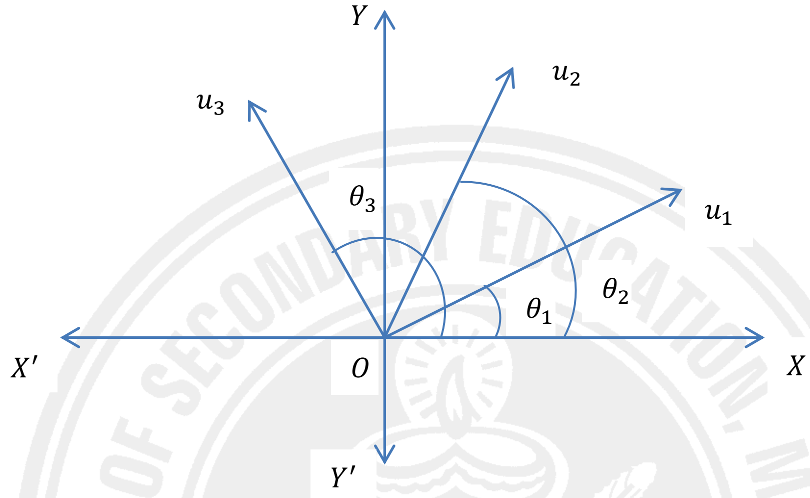
Let *ABCDEF* be a polygon and there be a particle having simultaneous velocities which can be represented in magnitude and direction by the sides *AB*, *BC*, *CD*, *DE* and *EF*. Then, the resultant velocity is represented in magnitude and direction by the side *AF*.

Thus, $\overrightarrow{AB} + \overrightarrow{BC} + \overrightarrow{CD} + \overrightarrow{DE} + \overrightarrow{EF} = \overrightarrow{AF}$



8. The Resultant of a number of simultaneous co-planar velocities of a particle:

Let a particle at O has velocities $u_1, u_2, u_3, \ldots u_n$ making respectively angles $\theta_1, \theta_2, \theta_3, \ldots \theta_n$ with a suitably chosen direction OX in the plane. And let OY be perpendicular to OX.



If X and Y respectively denote the algebraic sums of all components along OX and OY,

Then $X = u_1 \cos\theta_1 + u_2 \cos\theta_2 + u_3 \cos\theta_3 + \ldots + u_n \cos\theta_n$

And, $Y = u_1 \sin\theta_1 + u_2 \sin\theta_2 + u_3 \sin\theta_3 + \ldots + u_n \sin\theta_n$

Then, the resultant velocity w is given by the relation $w = \sqrt{X^2 + Y^2}$ ----- (i)

And, the angle θ made by w with OX is given by $\tan\theta = \frac{Y}{X}$ ------ (ii)

Equations (i) and (ii) give respectively the magnitude and direction of the resultant velocity.

KEYNOTE 8.3

1. **Momentum**: When a body is in motion, it acquires a certain property by virtue of its motion. This property which is depending on both amount of the mass and velocity of the body is called the momentum of the body.
   $\therefore$ Momentum = mass × velocity.
2. **Force**: A force is an external agent that changes or tends to change the state of rest or state of uniform motion along a straight line of a body.

3. Newton's laws of motion:

a) First law: Everybody continues in its state of rest or of uniform motion in a straight line, except in so far as it is compelled by external forces to change that state.

b) Second law: The rate of change of momentum is proportional to the motive force and takes place in the direction of the straight line in which the force acts.

We have, $p = mf$

c) Third law: To every action, there is an equal and opposite reaction.

4. Weight: The weight of a body is the resultant force with which the body is attracted towards the centre of the Earth.

The weight W of a body of mass m , $W = mg$

Notes:

(i) The equation $P = mf$ is sometimes called the ***kinetic equation.***

(ii) Units of force:

In the FPS system, the unit of force is poundal.

In the CGS system, the unit of force is dyne.

In the MKS system, the unit of force is Newton.

($1N=10^5$ dynes, 1 megadyne = 10^6 dynes = 10N)

(iii) Gravitational unit of force: The unit of force expressed in terms of the gravitational pull on the mass is called the gravitational or statical unit of force.

e.g. A body of mass 1 lb on the surface of the earth is attracted to the centre of the earth by a force called 1 pound weight denoted by 1 lb.wt.

$\therefore$ Using $P = mf$, this force, 1 lb.wt. $= 1 \times 32 = 32\ poundals$.

Similarly,

1 gm . wt	=	981 dynes
1 kg . wt	=	9.81 Newtons

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