AL MUSTAQBAL UNIVERSITY

ENGINEERING TECHNICAL COLLEGE

DEPARTMENT OF BUILDING & CONSTRUCTION ENGINEERING TECHNOLOGIES

ENGINEERING PHYSICS

FIRST CLASS

LECTURE NO. 3

ASST. LECTURER

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Chapter 2

FORCE AND MOTION

2.1 SCALAR AND VECTOR QUANTITIES

Scalar Quantities: Scalar quantities are those quantities which are having only magnitude but no direction.

Examples: Mass, length, density, volume, energy, temperature, electric charge, current, electric potential etc.

Vector Quantities: Vector quantities are those quantities which are having both magnitude as well as direction.
Examples: Displacement, velocity, acceleration, force, electric intensity, magnetic intensity etc.

Representation of Vector: A vector is represented by a straight line with an arrow head. Here, the length of the line represents the magnitude and arrow head gives the direction of vector.

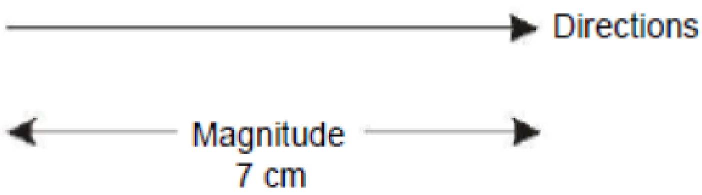

Figure:2.1

Types of Vectors

Negative Vectors: The negative of a vector is defined as another vector having same magnitude but opposite in direction.

i.e., any vector $\vec{A}$ and its negative vector $[-\vec{A}]$ are as shown.

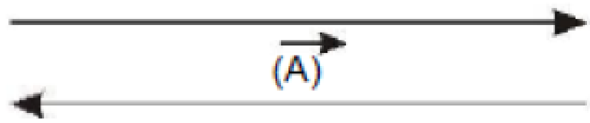

Figure:2.2

Equal Vector: Two or more vectors are said to be equal, if they have same magnitude and direction. If $\vec{A}$ and $\vec{B}$ are two equal vectors then

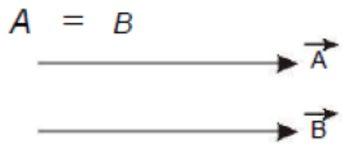

Figure:2.3

Unit Vector: A vector divided by its magnitude is called a unit vector. It has a magnitude one unit and direction same as the direction of given vector. It is denoted by $\hat{A}$.

$$\hat{A} = \vec{A} / A$$

Collinear Vectors: Two or more vectors having equal or unequal magnitudes, but having same direction are called collinear vectors.

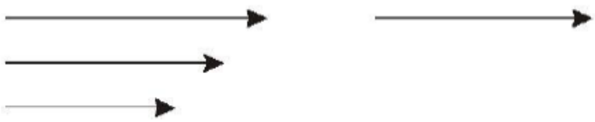

Figure:2.4

Zero Vector: A vector having zero magnitude and arbitrary direction (be not fixed) is called zero vector. It is denoted by O.

2.2 ADDITION OF VECTORS, TRIANGLE & PARALLELOGRAM LAW

Addition of Vectors

(i) Triangle law of vector addition.

If two vectors can be represented in magnitude and direction by the two sides of a triangle taken in the same order, then the resultant is represented in magnitude and direction, by third side of the triangle taken in the opposite order (Fig. 2.5).

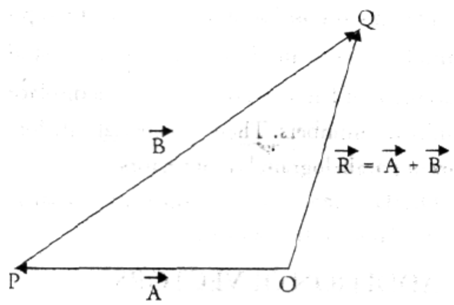

Figure:2.5

Magnitude of the resultant is given by

$$R = \surd A2 + B2 + 2AB\cos\theta$$

And direction of the resultant is given by

$$\tan\beta = B\sin\theta\, A + B\cos\theta$$

(ii) Parallelogram (||gm) law of vectors:

It states that if two vectors, acting simultaneously at a point, can have represented both in magnitude and direction by the two adjacent sides of a parallelogram, the resultant is represented by the diagonal of the parallelogram passing through that point (Fig. 2.6).

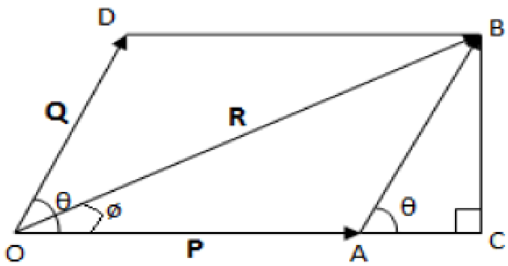

Figure:2.6

Magnitude of the resultant is given by

$$R = \surd P2 + Q2 + 2PQ\cos\theta$$

And direction of the resultant is given by

$$\tan\phi = Q\sin\theta P + Q\cos\theta$$

2.3 SCALAR AND VECTOR PRODUCT

Multiplication of Vectors

(i) **Scalar (or dot) Product:** It is defined as the product of magnitude of two vectors and the cosine of the smaller angle between them. The resultant is scalar. The dot product of vectors $A^{\rightarrow}$ and $B^{\rightarrow\rightarrow}$ is defined as

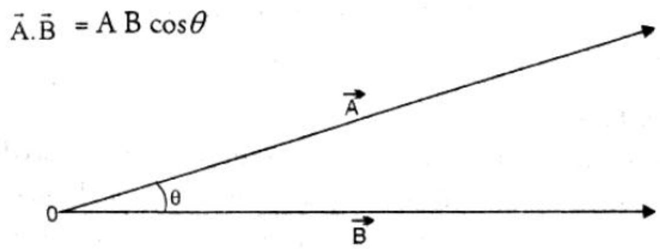

Figure:2.7

(ii) **Vector (or Cross) Product:** It is defined as a vector having a magnitude equal to the product of the magnitudes of the two vectors and the sine of the angle between them and is in the direction perpendicular to the plane containing the two vectors.

Thus, the vector product of two vectors A and B is equal to

$$\vec{A} \times \vec{B} = AB\ sin\theta\ \hat{n}$$

2.4 DEFINITION OF DISTANCE, DISPLACEMENT, SPEED, VELOCITY, ACCELERATION

Distance: How much ground an object has covered during it motion. Distance is a scalar quantity. SI unit is meter.

Displacement: The shortest distance between the two points is called displacement. It is a vector quantity.
SI unit is meter.
Dimension formula: [L]

Speed: *The rate of change of distance is called speed. Speed is a scalar quantity.*
Unit: ms^{-1}.
Linear Velocity: *The time rate of change of displacement*.

$$v = displacement\ /\ time$$

Units of Velocity: ms^{-1}
Dimension formula = $[M^0L^1T^{-1}]$

Acceleration: The change in velocity per unit time. i.e. the time rate of change of velocity.

$$A = Change\ in\ Velocity\ /\ time$$

If the velocity increases with time, the acceleration 'a' is positive. If the velocity decreases with time, the acceleration 'a' is negative. Negative acceleration is also known as retardation.

Units of Acceleration:
C.G.S. unit is cm/s^2 (cms^{-2}) and the SI unit is m/s^2 (ms^{-2}).
Dimension formula = $[M^0L^1T^{-2}]$

2.5 FORCE AND ITS UNITS, CONCEPT OF RESOLUTION OF FORCE

Force: Force is an agent that produces acceleration in the body on which it acts. Or it is a push or pull which change or tends to change the position of the body at rest or in uniform motion.

Force is a vector quantity as it has both direction and magnitude. For example,
(i) To move a football, we have to exert a push i.e., kick on the football
(ii) To stop football or a body moving with same velocity, we have to apply push in a direction opposite to the direction of the body.

SI unit is Newton.

Dimension formula: $[MLT^{-2}]$.

Resolution of a Force

The phenomenon of breaking a given force into two or more forces in different directions is known as 'resolution of force'. The forces obtained on splitting the given force are called components of the given force.

If these are at right angles to each other, then these components are called rectangular components.

Let a force F be represented by a line OP. Let OB (or F_x) is component of F along x-axis and OC (or F_y) is component along y-axis (Fig. 2.8).

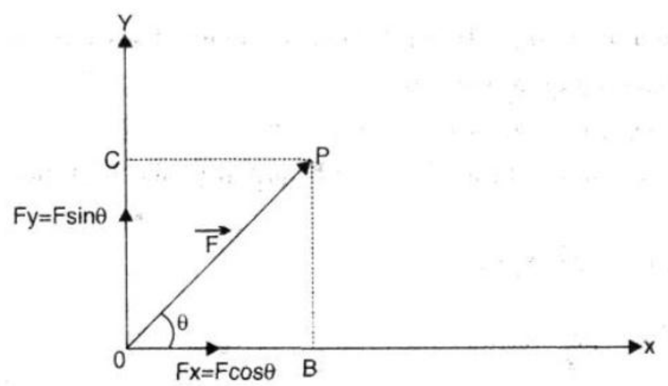

Figure:2.8

Let force F makes an angle θ with x-axis.

In Δ OPB

$\sin\theta = PB / OP$

$PB = OP \sin\theta$

$F_y = F \sin\theta$

$\cos\theta = OB / OP$

$OB = OP \cos\theta$

$F_x = F \cos\theta$

Vector $\vec{F} = \vec{F}_x + \vec{F}_y$

Resultant: $F = \sqrt{F_x^2 + F_y^2}$