UNIT 1 – KINEMATICS

GREETINGS Students, This class we are going to discuss about Motion in One, Two and Three Dimensions, elementary concepts of vector algebra.

Motion in One, Two and Three Dimensions

Let the position of a particle in space be expressed in terms of rectangular coordinates x, y and z.

(i) Motion in one dimension

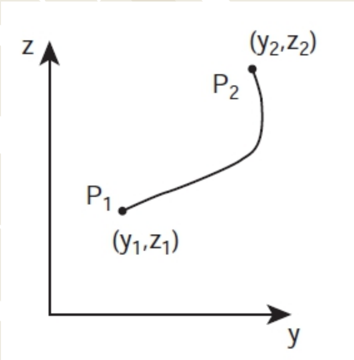
One dimensional motion is the motion of a particle moving along a straight line.

Examples

- Motion of a train along a straight railway track.
- An object falling freely under gravity close to Earth.

(ii) Motion in two dimensions

If a particle is moving along a curved path in a plane, then it is said to be in two dimensional motion.



Examples

- Motion of a coin on a carrom board.
- An insect crawling over the floor of a room.

(iii) Motion in three dimensions

A particle moving in usual three dimensional space has three dimensional motion.

Examples

- A bird flying in the sky.
- Random motion of a gas molecule.
- Flying of a kite on a windy day.

URL: https://www.youtube.com/watch?v=ydLOOubiABA&feature=youtu.be

ELEMENTARY CONCEPTS OF VECTOR ALGEBRA

Some quantities possess only magnitude and some quantities possess both magnitude and direction. It is very important to know the properties of vectors and scalars.

Scalar

It is a property which can be described only by magnitude. In physics a number of quantities can be described by scalars.

Examples

Distance, mass, temperature, speed and energy.

Vector

It is a quantity which is described by both magnitude and direction.

Examples

Force, velocity, displacement, position vector, acceleration, linear momentum and angular momentum.

Magnitude of a Vector

"The length of a vector is called magnitude of the vector. It is always a positive quantity. Sometimes the magnitude of a vector is also called 'norm' of the vector. For a vector →, the magnitude or norm is denoted by | → | or simply '*A*'"

Different types of Vectors

1. **Equal vectors:**

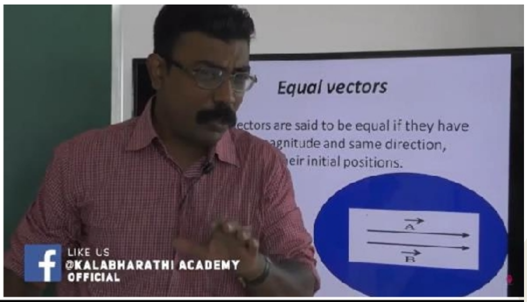
Two vectors → and → → are said to be equal when they have equal magnitude and same direction and represent the same physical quantity .

(a) **Collinear vectors**: Collinear vectors are those which act along the same line. The angle between them can be 0° or 180°.

2. **(i) Parallel Vectors**:

If two vectors →, and → →, act in the same direction along the same line or on parallel lines, then the angle between them is 0^0

(ii) Anti–parallel vectors: Two vectors and are said to be anti–parallel when they are in opposite directions along the same line or on parallel lines. Then the angle between them is 180^0



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1 **Unit vector**: A vector divided by its magnitude is a unit vector. The unit vector for *is denoted by* (read as A cap or A hat). It has a magnitude equal to unity or one.

$$\text{Since, } \hat{A} = \frac{\vec{A}}{A} \text{ we can write } \vec{A} = A\hat{A}$$

Thus, we can say that the unit vector specifies only the direction of the vector quantity.

Orthogonal unit vectors:

Let , *and* be three unit vectors which specify the directions along positive *x* axis, positive *y*–axis and positive *z*–axis respectively.

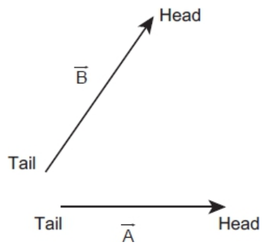
These three unit vectors are directed perpendicular to each other, the angle between any two of them is 90°.

Addition of Vectors

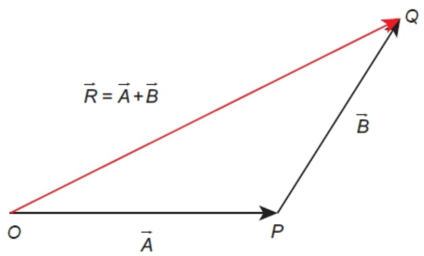
Since vectors have both magnitude and direction they cannot be added by the method of ordinary algebra. Thus, vectors can be added geometrically or analytically using certain rules called ‘vector algebra’.

- **Triangular Law of addition method**
- **Parallelogram law of vectors.**

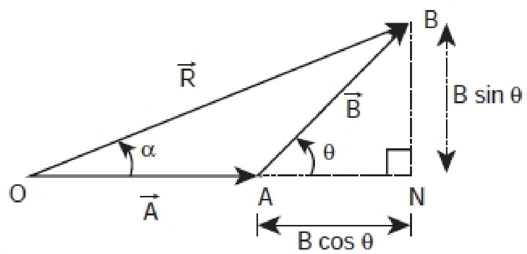
Triangular Law of addition method



Head and tail of vectors



(1) Magnitude of resultant vector



$$\cos\theta = \frac{AN}{B} \therefore AN = B\cos\theta \ and$$

$$\sin\theta = \frac{BN}{B} \quad \therefore BN = B\sin\theta$$

For ΔOBN, we have $OB^2 = ON^2 + BN^2$

$$\Rightarrow R^2 = (A + B\cos\theta)^2 + (B\ \sin\theta)^2$$

$$\Rightarrow R^2 = A^2 + B^2\cos^2\theta + 2AB\cos\theta + B^2\sin^2\theta$$

$$\Rightarrow R^2 = A^2 + B^2\left(cos^2\theta + sin^2\theta\right) + 2AB\cos\theta$$

$$\Rightarrow R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$

which is the magnitude of the resultant of $\vec{A}$ and $\vec{B}$

(2) Direction of resultant vectors: If θ is the angle between ⃗ and ⃗ ⃗ , then

$$\left|\vec{A}+\vec{B}\right| = \sqrt{A^2 + B^2 + 2AB\cos\theta} \quad (2.1)$$

If $\vec{R}$ makes an angle α with $\vec{A}$, then in ΔOBN,

$$\tan\alpha = \frac{BN}{ON} = \frac{BN}{OA+AN}$$

$$\tan\alpha = \frac{B\sin\theta}{A+B\cos\theta}$$

$$\Rightarrow \alpha = \tan^{-1}\left(\frac{B\sin\theta}{A+B\cos\theta}\right)$$

Topic to be learned in this video

Triangle Law of Vector addition

URL: https://www.youtube.com/watch?v=10cudYfaI5Q&feature=youtu.be