Unit 1.3 Vectors and scalar

Scalars

1. The quantities, which need only size or magnitude to completely specify them, are called scalars. E.g. mass, temperature, energy or work etc.

Vectors

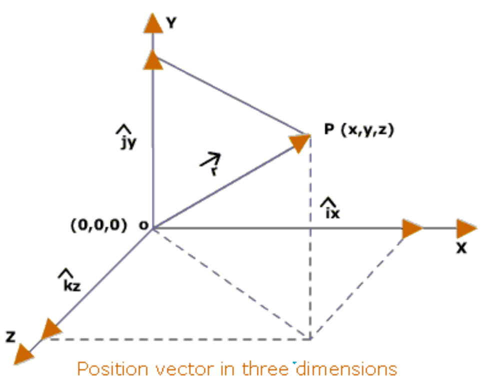
1. The quantities which need direction in addition to magnitude to completely specify them are called vectors. E.g. displacement, force etc.
2. They should obey the law of vector addition. Current is a scalar quantity even though it has direction. Because it does not obey the law of vector addition.

Representation of vectors

1. Symbolic- We write vectors by italic boldface or arrow above the symbol e.g. ***V*** or $\vec{V}$.
2. Magnitude- e.g.V or $|\vec{V}|$
3. Graphically- By a line with an arrow head at one end. The length of line is proportional to the magnitude and the arrow head gives the direction.

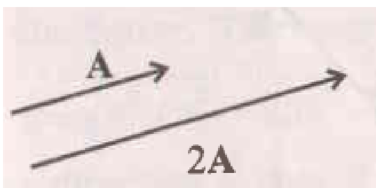
Some Important Vectors

1. Equal Vectors: - They have same magnitudes and directions.
2. Opposite Vectors: - They have same magnitudes but opposite directions.
3. Null Vector: - It has zero magnitude but direction undetermined. It is denoted by $\vec{0}$.
4. Unit Vector: - Magnitude unity & direction same as given vector. Actually, a unit vector represents the direction of the given vector. E.g.$\hat{\imath}, \hat{a}$ etc.
5. Position Vector: - Vector describing the position of a particle. Suppose a particle is situated at (x, y, z) in space, its position vector will be;
$\overrightarrow{OP}$ or $\vec{r} = x\,\hat{\imath} + y\,\hat{\jmath} + z\,\hat{k}$.



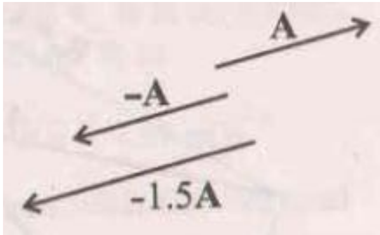
Position vector in three dimensions

Multiplication of vector by a scalar



1. Multiplying a vector $\vec{A}$ by a positive number λ gives a vector whose magnitude is changed by the factor λ but the direction is the same as that of $\vec{A}$.

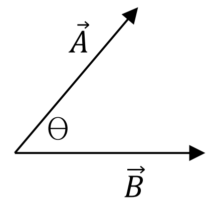
2. Multiplying a vector $\vec{A}$ by a negative number λ gives a vector $\lambda\vec{A}$ whose direction is the opposite to that of $\vec{A}$ and magnitude is $-\lambda$ times $|\vec{A}|$.

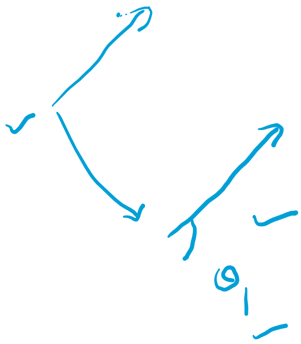


3. The factor λ by which a vector $\vec{A}$ is multiplied could be a scalar having its own physical dimensions. Then the dimension of $\lambda\vec{A}$ is the product of the dimensions of λ *and* $\vec{A}$. E.g. if we multiply a constant velocity vector by duration (time) then we get a displacement vector.

Angle between two Vectors

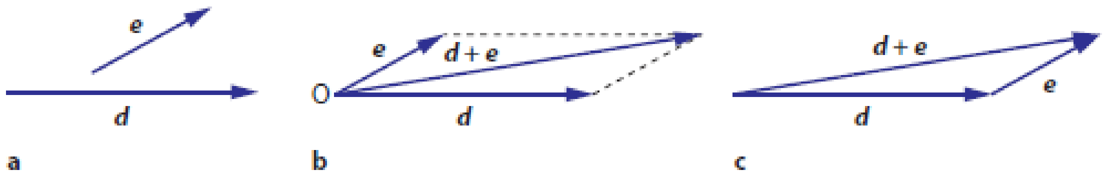
1. Smaller of the angles between the two vectors when they are joined tail to tail.





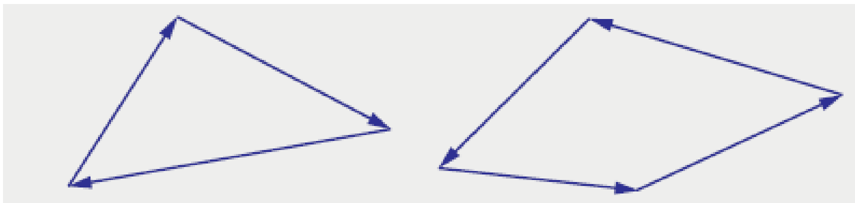
Addition of vectors

1. There are two methods of adding vectors;
   a) Parallelogram method: - Suppose we have to add two vectors ***d*** and ***e***. Draw them so they start at a common point O. Complete the parallelogram whose sides are ***d*** and ***e***. Draw the diagonal of this parallelogram starting at O. this is the vector $\boldsymbol{d} + \boldsymbol{e}$.



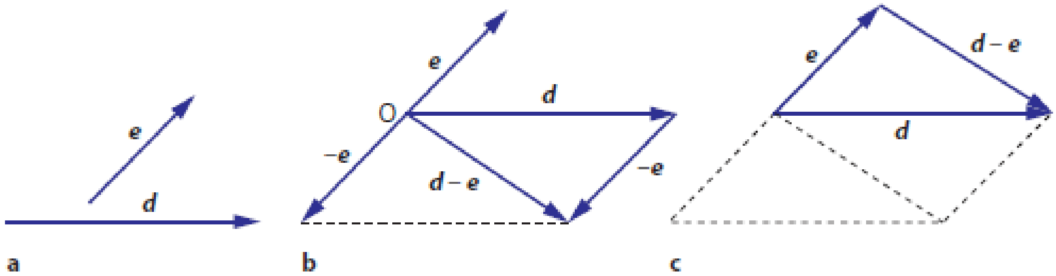
b) Triangle method: - Join the head of first vector with the tail of second vector and then you will be left with the tail of first vector with the head of second vector. These head and tail will become the head and tail of the resultant vector as shown in figure c.

2. Vectors (with arrows pointing in the same sense) forming closed polygons add up to zero.



Subtraction of vectors

1. To get a vector $\boldsymbol{d} - \boldsymbol{e}$ we add $\boldsymbol{d}$ and $-\boldsymbol{e}$ as shown in figure below.

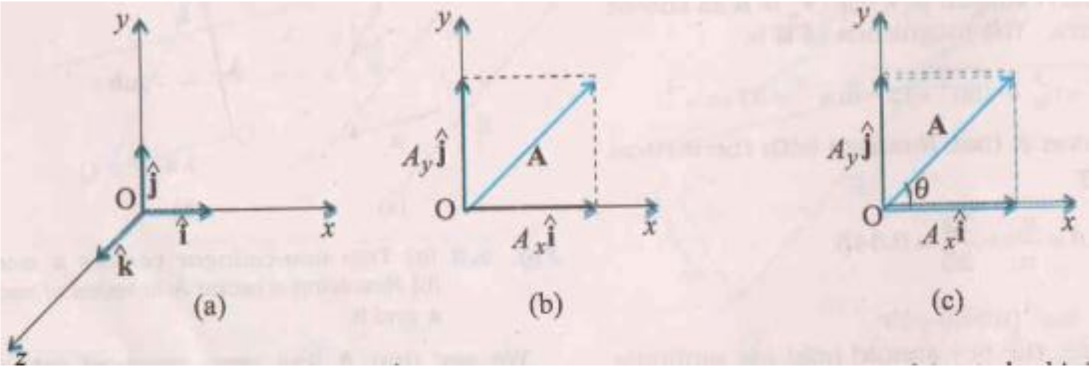


2. *Second method*: - Join them tail to tail then make head of $\boldsymbol{d}$ and tail of $\boldsymbol{e}$ the head and tail of the resultant i.e. $\boldsymbol{d} - \boldsymbol{e}$.

Components of a vector

1. It is convenient to resolve a general vector along the axes of a rectangular coordinate system using unit vectors. The components so obtained are called rectangular components of the given vector.

We can now resolve a vector $\vec{A}$ in terms of the component vectors that lie along unit vectors $\hat{\imath}$ *and* $\hat{\jmath}$.



Consider a vector $\vec{A}$ that lies in the $X - Y$ plane as shown in figure. We draw lines from the head of $\vec{A}$ perpendicular to the coordinate axes, as shown in fig., to get vectors $\vec{A}_1$ *and* $\vec{A}_2$ such that $\vec{A}_1 + \vec{A}_2 = \vec{A}$. Since $\vec{A}_1$ is parallel to $\hat{\imath}$ and $\vec{A}_2$ is parallel to $\hat{\jmath}$, we have;

$\vec{A}_1 = A_x\hat{\imath}$ *and* $\vec{A}_2 = A_y\hat{\jmath}$

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

It is shown in fig. The quantities A_x *and* A_y are called $x -$ *and* $y -$ components of the vector $\vec{A}$.

We can express A_x *and* A_y in terms of A *and* θ as follows;

$A_x = A\ \cos\theta \ ----(1)$

$A_y = A\ \sin\theta ----(2)$

2. In above eq[n] (1) and (2), the angle θ is the angle made by the given vector with positive $x\ axis$ but sometimes the angle may be given with negative x axis as shown the following figures. In that case make the component and assign proper sign i.e. if on resolving the component is coming along negative $x\ axis$ then give minus sigh to it.

Reconstructing a vector from its components

1. We can also express A *and* θ in terms of A_x *and* A_y as follows;

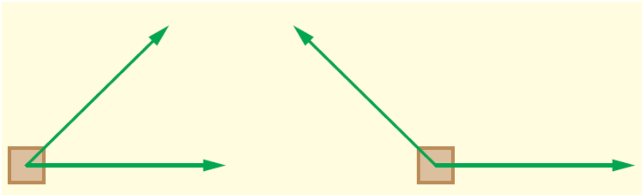
   $A_x^2 + A_y^2 = A^2(cos^2\theta + sin^2\theta) = A^2$

   $Or\ \ A = \sqrt{A_x^2 + A_y^2}$

   And $\theta = \tan^{-1}\left(\frac{A_y}{A_x}\right)$

Assignment 1_IBDPy1_22nd June2020_Phy_Topic 1.3

Q1. A body is acted upon by the two forces shown in the diagram. In each case draw the one force whose effect on the body is the same as the two together.



Q2. Vector ***A*** has a magnitude of 12.0 units and makes an angle of 30° with the positive *x*-axis. Vector ***B*** has a magnitude of 8.00 units and makes an angle of 80° with the positive *x*-axis. Using a graphical method, find the magnitude and direction of the vectors:

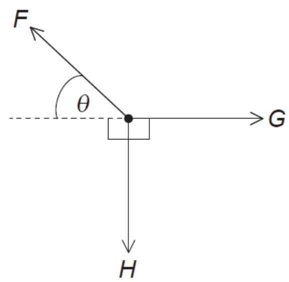
a) $A + B$

b) $A - B$

c) $A - 2B$

Phy_IBDP y1_MCQ_1.3_29th June_Assignment 3 *[8 marks]*

1. An object is held in equilibrium by three forces of magnitude *F, G* and *H* that act at a point in the same plane. *[1 mark]*



Three equations for these forces are

I. $F \cos \theta = G$
II. $F = G \cos \theta + H \sin \theta$
III. $F = G + H$

Which equations are correct?

A. I and II only

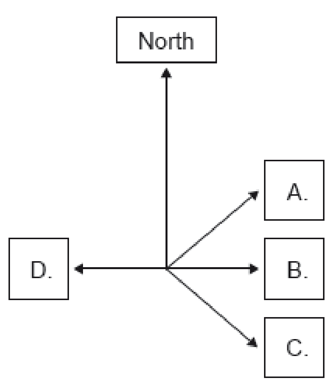
B. I and III only

C. II and III only

D. I, II and III

2. A river flows north. A boat crosses the river so that it only moves in the direction east of its starting point. *[1 mark]*

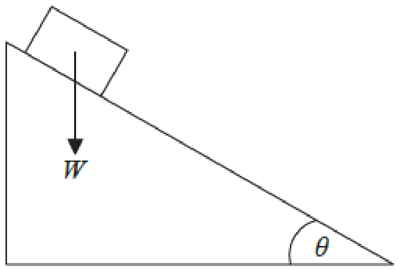
What is the direction in which the boat must be steered?



3. Which of the following lists three vector quantities? *[1 mark]*

A. momentum, electric field strength, displacement
B. momentum, displacement, pressure
C. pressure, electric current, displacement
D. electric current, electric field strength, impulse

4. An object slides down an inclined plane that makes an angle θ with the horizontal. The weight of the object is W. *[1 mark]*



Which of the following is the magnitude of the component of the weight parallel to the plane?

A. $W \sin \theta$

B. $\frac{W}{\sin\theta}$

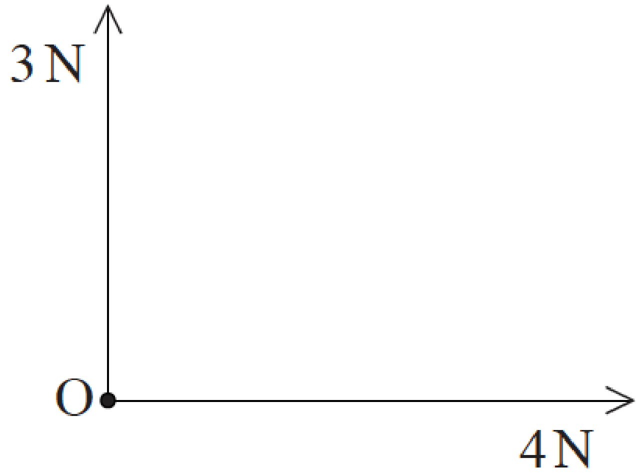
C. $W \cos \theta$

D. $\frac{W}{\cos\theta}$

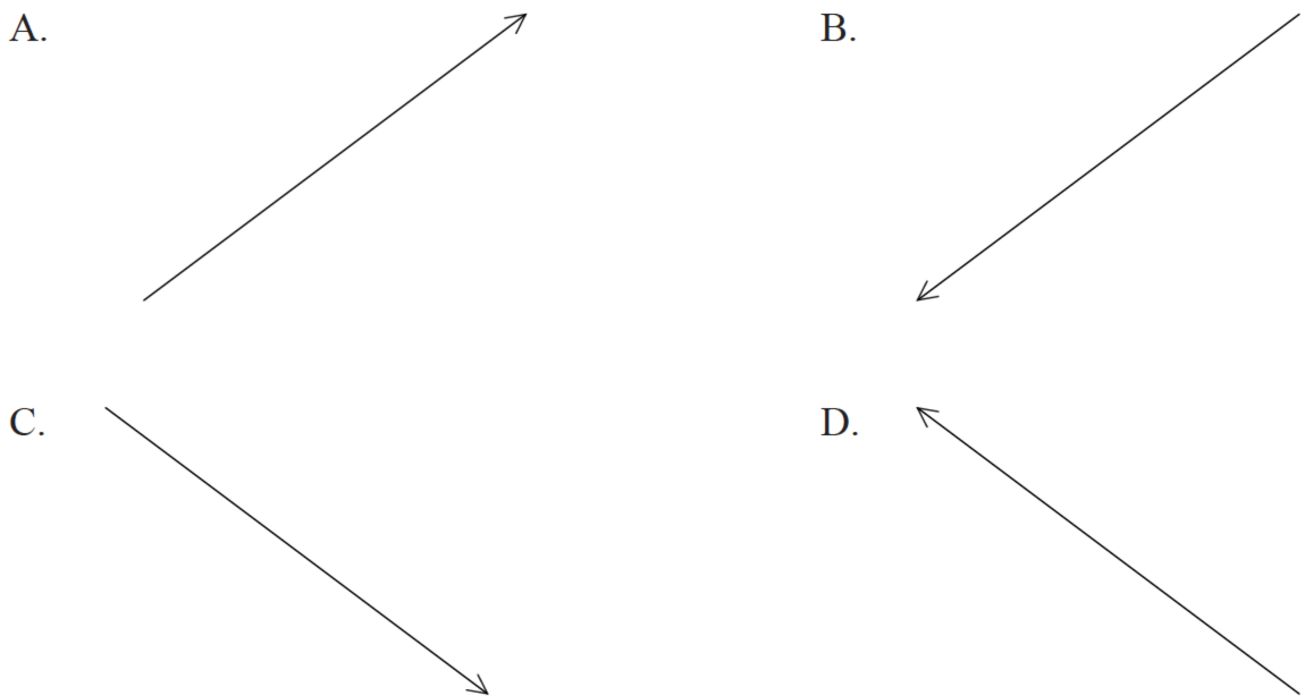
5. A ball is thrown with velocity u at an angle of 55° above the horizontal. Which of the following is the magnitude of the horizontal component of velocity? *[1 mark]*

A. $u \cos 55°$
B. $u \sin 55°$
C. u
D. $u \tan 55°$

6. The vector diagram shows two forces acting on a point object O. The forces are in the plane of the page. *[1 mark]*



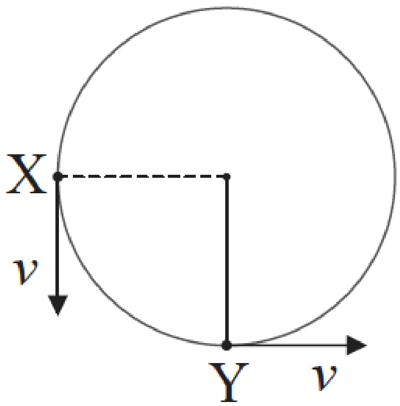
Another 5 N force is applied to O in the plane of the page. Which of the following gives the direction of this force to ensure that O is in equilibrium?



7. Which of the following lists **two** scalar quantities? *[1 mark]*

1. emf, momentum
2. emf, weight
3. impulse, kinetic energy
4. temperature, kinetic energy

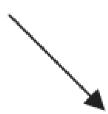
8. A stone attached to a string is moving in a horizontal circle. The constant speed of the stone is *v*. The diagram below shows the stone in two different positions, X and Y. *[1 mark]*



Which of the following shows the direction of the change of velocity of the stone when moving from position X to position Y?

A. 

B. 

C. 

D.