Scalars and Vectors

Physical Quantities:

All those quantities which can be measured are called physical quantities. Physical Quantities can be measured by means of magnitude and units.

Magnitude:

A symbol which gives us the quantity of substance is called magnitude.

Unit:

A symbol which gives its relation is called unit. e.g.

5 KG 5: Magnitude Kg: Unit

10 N 10: Magnitude N : Unit

Type of Physical Quantities:

Physical quantities are of two types.

(i) Scalar quantities (ii) Vector Quantities

(i) Scalar Quantities:

Definition:

"All those physical quantities which are completely specified when only magnitude with suitable units is given are called scalar quantities".

OR

"Quantities which can be specified by number having appropriate units are scalar quantities".

Example:

Mass, Distance, Time, Speed, Energy, Temperature, Work, Volume, density, etc.

(ii) Vector Quantities: "All those physical quantities which are completely specified only when both magnitudes with suitable units as well as direction are called vector quantity".

OR

"Quantities having both magnitude and direction with appropriate units are called Vector quantities".

Example:

Displacement, velocity, acceleration, force, weight, momentum, torque, etc.

Vector Representation:

A vector is represented graphically by a directed line segment or an arrow head segment. The length of arrow represents the magnitude while arrowhead represents the direction. Representation of vector can be performed in three steps.

Step I: "Suitable Scale"

In this step we choose suitable scale in order to represent the given vector.

$\hat{A}$ ⟶

Step II: "Reference axis"

In this step we represent the direction of given vector in reference axis.

N

W ———————|——————— E

S
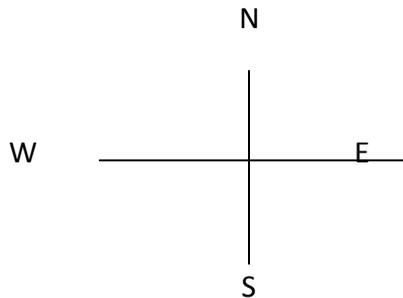
Step III: "Representation"

In this step we represent the given vector by the help of above chosen scale and indicated direction.

Negative of a vector:

Negative vector is defined as:

"A vector just equal in magnitude but exactly opposite in direction is called negative of a vector."

OR

"A vector having the same magnitude as that of a given vector but opposite in direction is called negative of a vector."

Example:

Negative of a A

Vector A is −A

A ⟶   −A ⟶
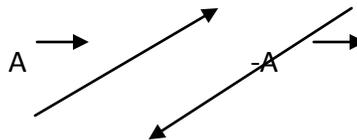
Addition of Vectors by Head to Tail Rule:

Consider two vectors A and B represented by lines OP and OQ respectively as shown in figure we can and these two vectors by placing the tail of second vector to the head of first vector.

Now join the tail of first vector to the head of last vector, it gives us the Resultant vector as shown in Fig.
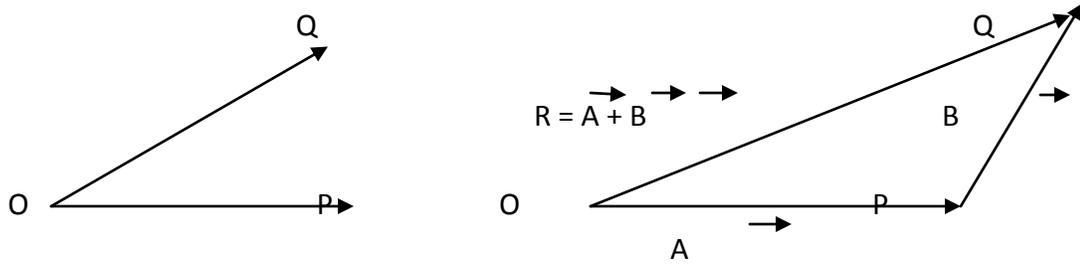
If more than two vectors are to be added than same method will be adopted for that. First draw the first vector than place the second vector so that its tail is at the head of First vector. Now add all the vectors just by joining the head of first vector to the tail of Next vector and in last join the tail of first vector to the head of last vector it gives us Resultant vector as shown in figure.
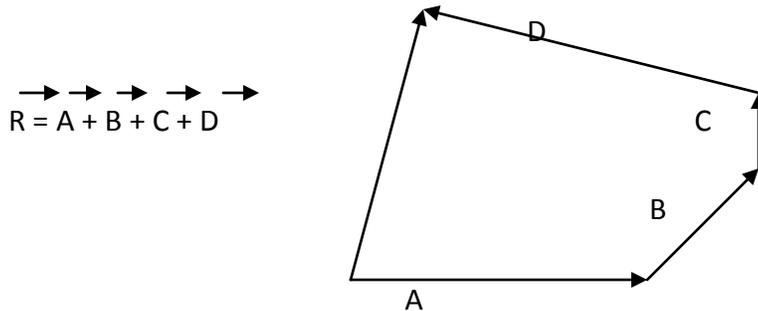
Resultant Vector:

"A vector which joins the tail of first vector to the head of last vector is called resultant Vector."

<div align="center">

OR

</div>

"A single vector which gives the combined effect of all the vectors which are to be added is called resultant vectors."

It can be represented by the following equation:

$$R = A + B + C + ………$$

Where R is the resultant vector, while A, B, C, are vectors to be added.

Subtraction of Vector:

Vectors cannot be subtracted directly. They are subtracted by means of addition. To subtract vector from another vector sign of the vector is changed and then added to the other vector. For example if a vector B is to be subtracted from a Vector: A then **A-B** is found by adding vector A and –B. Subtraction of vectors can be illustrated as follows:
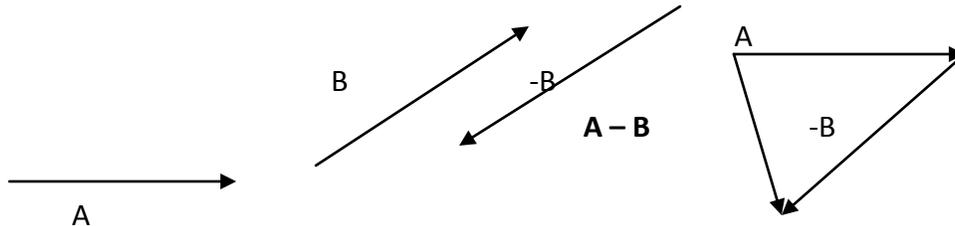
Trigonometry:

Trigonometry is an important branch of mathematics and is used to solve various problems in physics. Considering the right angle triangle ABC, angle <ABC is right angle and <BAC is denoted by Ø.

In the triangle
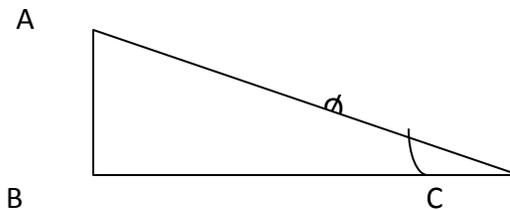
Base: (BC) Side adjacent to the angle Ø is called Base.

Perpendicular: (AB) Side opposite to the angle 0 is called Perpendicular.

Hypotenuse: (AC) Largest side or the side opposite to the right angle is called Hypotenuse

The ratios between any two sides of the right triangle represented by different names. Some of important ratios are as follows:

Sin Ø = Prep / Hyp   Cosec Ø = Hyp / Perp

Cos Ø = Base / Hyp   Sec Ø = Hyp / Base

Tan Ø = Perp / Base   Cot Ø = Base / Perp

The values of trigonometric ratios are changed if Ø is changed.

Resolution of Vector:

The process of splitting a vector into its parts (components) is called resolution of a vector. Generally a vector is resolved into two components at right angle to each other Such components are called rectangular components.

Horizontal Component: The component which is along horizontal direction is called horizontal component.

Vertical Component: The Component which is along vertical direction is called vertical Component.

```
           B
        
    Fy        ⟍ F
              ⟍
    A _____ C
           Fx
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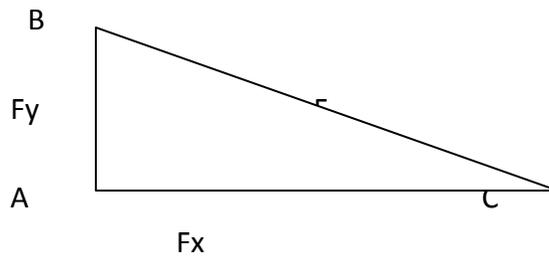
Consider a vector F, which shows the representative line AB making angle Ø with x-axis From B draw perpendicular BC on x-axis. Suppose AB and AC are represented by two Vectors. Vector BC is parallel to y-axis and y Vector AC is along x-axis. Hence we denote Vector AC by Fx and vector AB by Fy by Applying head to tail rule of vector addition, The sum of vectors Fx and Fy is equal to F. Therefore, FX and FY are rectangular components B of Vector F.

The magnitude of these components can be Fy determined by using trigonometric ratios.

Now considering right angle triangle ABC.

Horizontal Component / X-Component	Vertical component / Y-Component
Cos Ø = Base/Hyp	Sin Ø = Perp/Hyp
Cos Ø = AC/BC	Sin Ø = AB / BC
Cos Ø = Fx / F	Sin Ø = Fy / F
Fx = FCos Ø	Fy = FSin Ø

Addition of Rectangular Components of Vectors: OR

Composition of Vector:

Rectangular components of vector (components that are perpendicular to each other) can be joining together to form resultant vector or original vector.

Considering right angle triangle ABC. Where: Fx = AB = Base , Fy = BC = Perp, F = AC = Hyp

For magnitude of vector using Pythagoras theorem.

$$(H)^2 = (B)^2 + (P)^2$$
$$(AC)^2 = (AB)^2 + (BC)^2$$
$$AC = \sqrt{(AB)^2 + (BC)^2}$$
$$F = \sqrt{Fx^2 + Fy^2}$$

For direction of vector using trigonometric ratio:

$$\textbf{Tan Ø = Perp / Base}$$
$$\textbf{Tan Ø = BC / AC}$$
$$\textbf{Tan Ø = Fy / Fx}$$
$$\textbf{0 = Tan}^{-1}\textbf{ (Fy / Fx)}$$