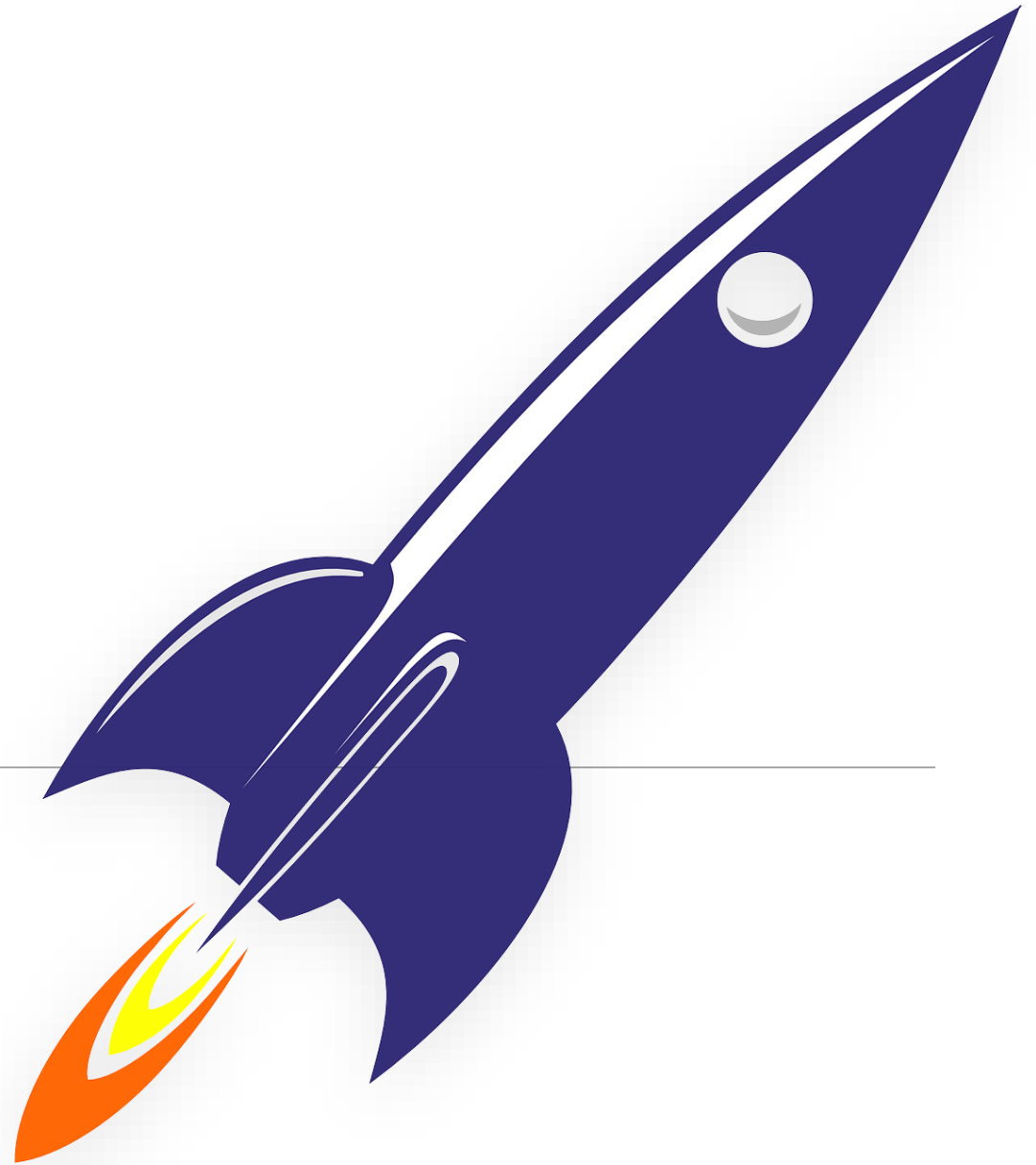


Mechanics-1A

Part 2

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Vectors & Scalars

Objectives:

4	understand scalar and vector quantities and know examples of each type of quantity and recognise vector notation
5	be able to resolve a vector into two components at right angles to each other by drawing and by calculation
6	be able to find the resultant of two coplanar vectors at any angle to each other by drawing, and at right angles to each other by calculation

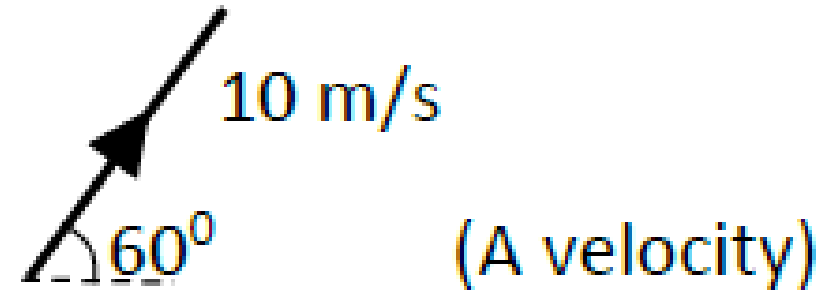
Vectors & Scalars

- ❑ A scalar quantity has only magnitude but no direction, such as distance, speed, mass, area, volume, time, work, energy, power, temperature, specific heat, charge, potential, pressure etc.

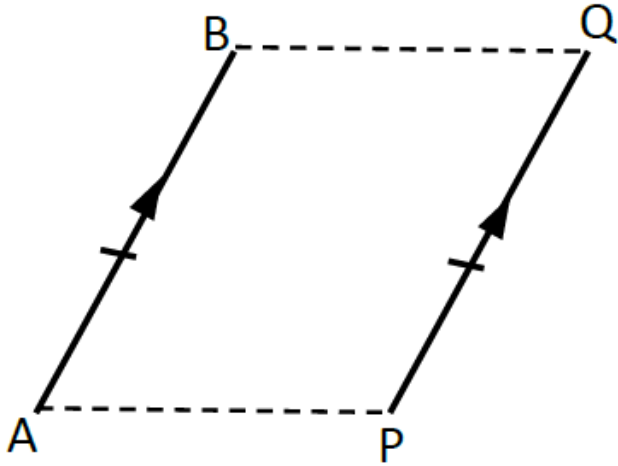
- ❑ A vector quantity has both magnitude and direction, such as displacement, velocity, acceleration, force, momentum, torque, electric field, magnetic field, etc.

- A vector represented by an arrow. The length of the arrow (on a convenient scale) is the magnitude of the vector and the direction in which the arrow points is the direction of the vector.
-

(A force)



Conditions for two Vectors to be equal.

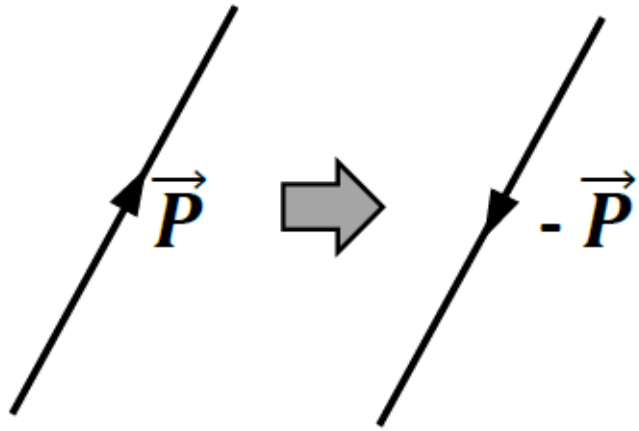


If $\vec{AB} = \vec{PQ}$,

- 1) They are the same type.
- 2) $AB = PQ$ (Same magnitude)
- 3) They are acting in the same direction.

- The opposite sides of a parallelogram can be used to represent two equal vectors.

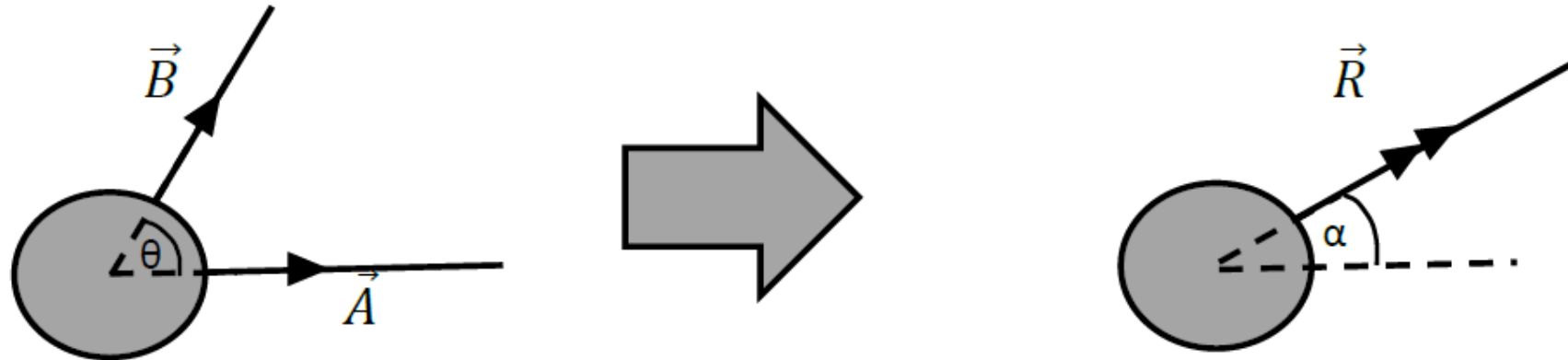
Multiplication by a negative sign



- If a vector is multiplied by a negative sign the magnitude of the vector remains the same, but its direction is reversed.

Addition of Vectors.

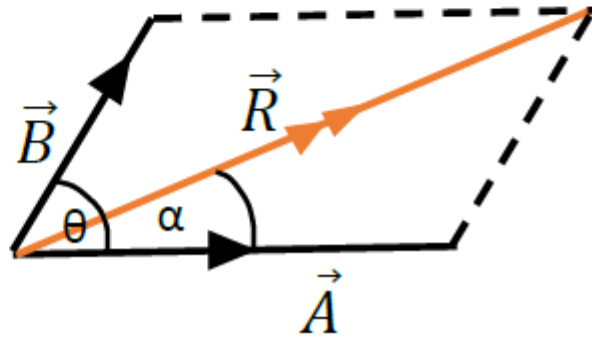
- The resultant of two or more vectors is a single vector (\vec{R}) which produces the same effect as the individual vectors together do.



- To find the resultant of two vectors, we use the parallelogram law of vector addition which may be stated as follows.

Parallelogram law of vector addition

- If the two vectors are represented in magnitude and direction by the two adjacent sides of a parallelogram drawn from a point, then their resultant is given in magnitude and direction by the diagonal of the parallelogram passing through the point.



If a scale diagram is drawn, the length of the arrow (diagonal) is the magnitude of the resultant vector and the direction in which the arrow(diagonal) points is the direction of the resultant vector.

- The magnitude R of the resultant vector R of two vectors A and B is given by

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

Where θ is the angle between the two vectors. The direction of the resultant \vec{R} is given by

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

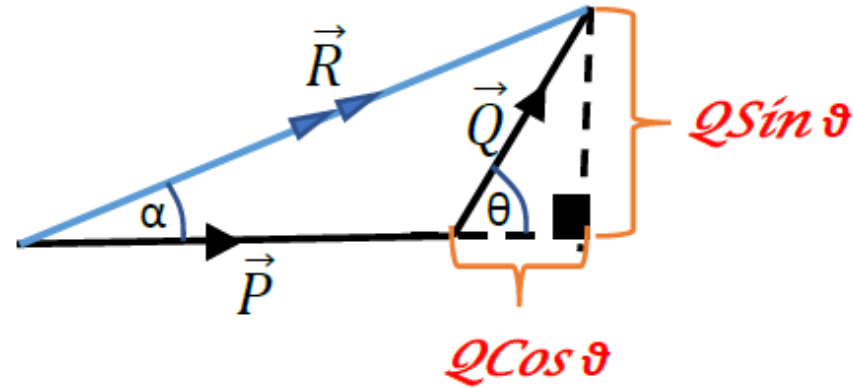
Vector triangle

If the two vectors are represented in magnitude and direction by the sides of a triangle taken in order, then the resultant is represented in magnitude and direction by the third side of the triangle taken in the opposite order.



$$\vec{P} + \vec{Q} = \vec{R}$$

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



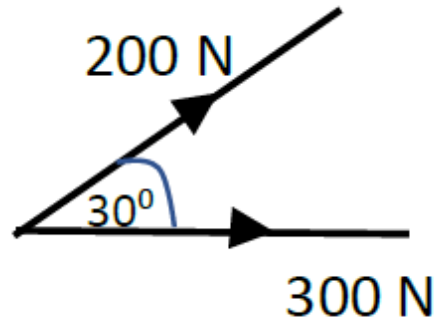
If a scale diagram is drawn, the length of the arrow (closing side) is the magnitude of the resultant vector and the direction in which the arrow (closing side) points is the direction of the resultant vector.

$$R = \sqrt{P^2 + Q^2 + 2PQ \cos \theta}$$

$$\tan \alpha = \frac{Q \sin \theta}{P + Q \cos \theta}$$

Concept Learning Questions:

Q: Find the resultant vector of the following vectors using the vector triangle method.

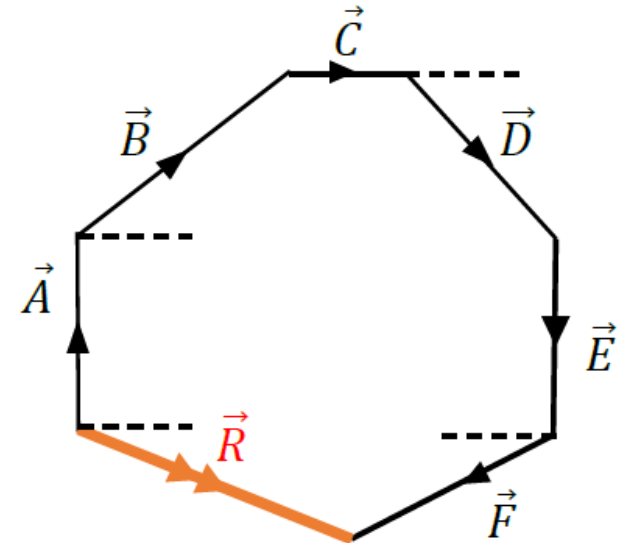
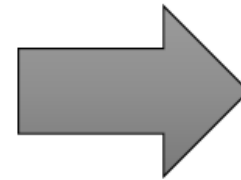
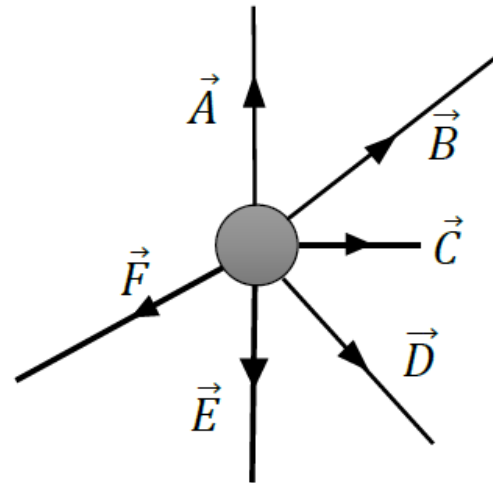


(Ans: $R=484\text{ N}$, $\alpha = 12^\circ$)

- To find the resultant of more than two vectors, we use the polygon law of vector addition which may be stated as follows:

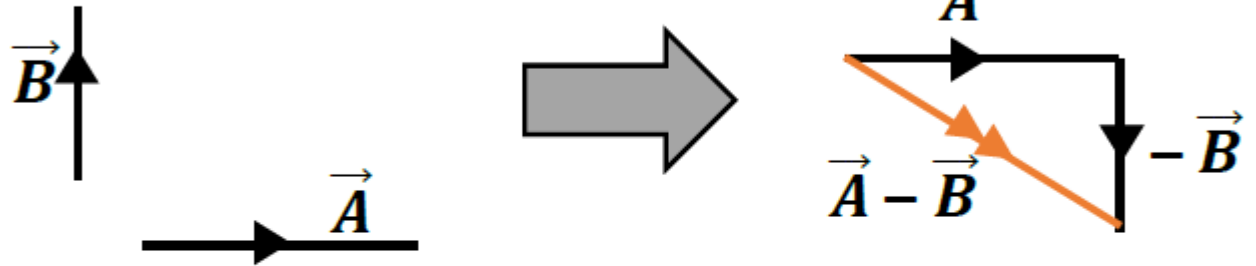
If a number of vectors are represented in magnitude and direction by the sides of polygon taken in order, then the resultant is represented in magnitude and direction by the closing side of the polygon taken in the opposite order.

If a scale diagram is drawn, the length of the arrow (closing side) is the magnitude of the resultant vector and the direction in which the arrow (closing side) points is the direction of the resultant vector.



Subtraction of Vectors.

- To subtract a vector B from A , reverse the direction of B and add it vectorially to A , *i.e.*

$$\vec{R} = \vec{A} - \vec{B} = \vec{A} + (-\vec{B})$$


Laws of vector addition

- Vector addition is commutative, *i.e.*

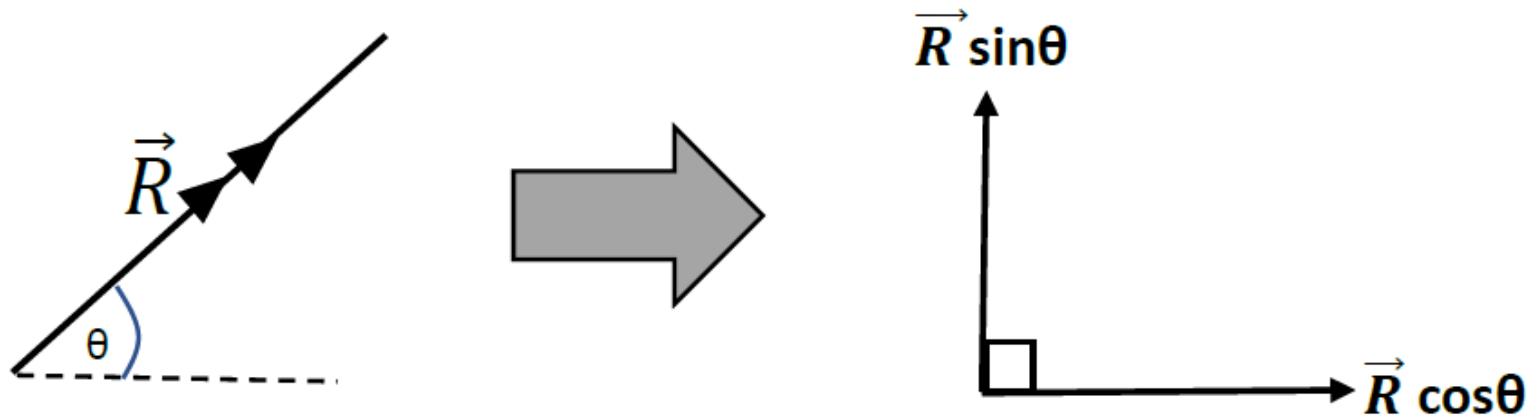
$$\vec{A} + \vec{B} = \vec{B} + \vec{A}$$

- Vector addition is associative, *i.e.*

$$(\vec{A} + \vec{B}) + \vec{C} = \vec{A} + (\vec{B} + \vec{C})$$

Resolution of a Vector.

- A vector can be resolved into two mutually perpendicular directions. The resolved part of the vector is its effective value in a given direction.
- The resolved part of a vector \vec{R} in a direction making an angle θ with \vec{R} is $\vec{R} \cos \theta$. The resolved part right angles to this direction is $\vec{R} \sin \theta$.
- $\vec{R} \sin \theta$ and $\vec{R} \cos \theta$ are called the components of vector \vec{R} .



Multiplication of a Scalar and a Vector.

- If a scalar and vector are multiplied the result is always a vector. The magnitude of the result is the product of the magnitudes, and the direction of the result is the direction of the vector quantity.

Example: Mass x Acceleration = Force

- Division of a vector and a scalar always results a vector.

Ex: $\frac{\textit{Displacement}}{\textit{Time}} = \textit{Velocity}.$

Multiple Choice Questions(MCQ)

- 1) Two vectors of the same physical quantity are equal if
- a) they have the same magnitude and the same direction
 - b) they have different magnitude but the same direction
 - c) they have the same magnitude but different direction
 - d) they have different magnitude and different direction

2) Given $\vec{A} = -\vec{B}$. This means the vectors \vec{A} and \vec{B}

- a) have equal magnitudes and in the same direction
- b) have unequal magnitudes and in the same direction
- c) have equal magnitudes and in the opposite directions
- d) have equal magnitudes and in the same direction

3) What happens if a vector is multiplied by a number 2?

- a) The magnitude of the vector is doubled but its direction remains the same
- b) The magnitude of the vector remains the same, but its direction reversed
- c) The magnitude of the vector is doubled, and its direction is reversed
- d) Neither the magnitude nor the direction of the vector undergoes any change.

4) The magnitude of the resultant of two equal vectors is equal to the magnitude of either vector. What is the angle between the two vectors?

a) 60°

b) 90°

c) 120°

d) 150°

5) Which of the following is a scalar quantity?

a) Weight

b) Pressure

c) Momentum

d) Velocity

Ans: 1) a, 2) c, 3) a, 4) c, 5) b