NCERT Solutions for Class-XI Physics

Chapter-4
NCERT Physics Class 11

1. State, for each of the following physical quantities, if it is a scalar or a vector:
Volume, mass, speed, acceleration, density, number of moles, velocity, angular frequency, displacement, angular velocity.

1. Answer 4.1:
Scalar: Volume, mass, speed, density, number of moles, angular frequency
Vector: Acceleration, velocity, displacement, angular velocity
A scalar quantity is specified by its magnitude only. It does not have any direction associated with it. Volume, mass, speed, density, number of moles, and angular frequency are some of the scalar physical quantities.
A vector quantity is specified by its magnitude as well as the direction associated with it.
Acceleration, velocity, displacement, and angular velocity belong to this category.

2. Pick out the only vector quantity in the following list:
Temperature, pressure, impulse, time, power, total path length, energy, gravitational potential, coefficient of friction, charge.

2. The two scalar quantities are work and current because they are defined by magnitude only.
NOTE: A scalar quantity is a quantity that is described by a magnitude or numerical value only.
Work has magnitude only. Although current has direction also, it is a scalar quantity because it follows general laws of algebra.

3. Pick out the only vector quantity in the following list:
Temperature, pressure, impulse, time, power, total path length, energy, gravitational potential, coefficient of friction, charge.

3. Impulse
Impulse is given by the product of force and time. Since force is a vector quantity, its product with time (a scalar quantity) gives a vector quantity.

4. State with reasons, whether the following algebraic operations with scalar and vector physical quantities are meaningful:
(a) adding any two scalars, (b) adding a scalar to a vector of the same dimensions, (c) multiplying any vector by any scalar, (d) multiplying any two scalars, (e) adding any two vectors, (f) adding a component of a vector to the same vector.

4. (a) Addition of two scalars is meaningful since both follow general algebraic laws.
(b) Addition of a scalar to a vector of the same dimensions is not meaningful since the scalar follows general algebraic laws but the vector does not.

(c) Multiplying any vector by a scalar is meaningful as the magnitude of the vector is multiplied by the scalar. For example, force which is a vector when multiplied by the scale time gives the vector impulse.

(d) Multiplying any two scalars is meaningful irrespective of their dimensions. For example, speed multiplied by time gives the distance travelled. Here, speed and time are scalars which give distance which is also a scalar.

(e) Addition of any two vectors is meaningful only if they have the same dimensions. This addition takes places according to vector algebra.

(f) Adding a component of a vector to the same vector is meaningful because both of them have the same dimensions.

NOTE: A scalar quantity is a quantity that is described by a magnitude or numerical value only. A vector quantity is a quantity that is described by both magnitude and direction.

5. Read each statement below carefully and state with reasons, if it is true or false:
(a) The magnitude of a vector is always a scalar, (b) each component of a vector is always a scalar, (c)the total path length is always equal to the magnitude of the displacement vector of a particle. (d) the average speed of a particle (defined as total path length divided by the time taken to cover the path) is either greater or equal to the magnitude of average velocity of the particle over the same interval of time, (e) Three vectors not lying in a plane can never add up to give a null vector.

5. (a) True (b) False
(c) False (d) True
(e) True

Explanation:

(a) The magnitude of a vector is a number. Hence, it is a scalar.

(b) Each component of a vector is also a vector.

(c) Total path length is a scalar quantity, whereas displacement is a vector quantity. Hence, the total path length is always greater than the magnitude of displacement. It becomes equal to the magnitude of displacement only when a particle is moving in a straight line.

(d) It is because of the fact that the total path length is always greater than or equal to the magnitude of displacement of a particle.

(e) Three vectors, which do not lie in a plane, cannot be represented by the sides of a triangle taken in the same order.

6. Establish the following vector inequalities geometrically or otherwise:

(a) $|a+b| \leq |a| + |b|$

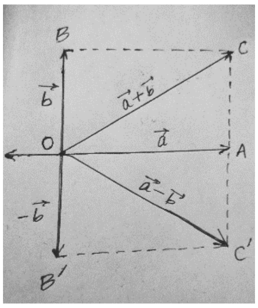
(b) $|a+b| \geq ||a| - |b||$

(c) $|a-b| \leq |a| + |b|$

(d) $|a-b| \geq ||a| - |b||$

When does the equality sign above apply?

6. Let us consider two vectors $\vec{a}$ and $\vec{b}$ such that $\overrightarrow{OA} = \vec{a}$ and $\overrightarrow{OB} = \vec{b}$. Also, $\overrightarrow{OB'} = -\vec{b}$. According to Parallelogram law of vector addition, $\overrightarrow{OC} = \vec{a} + \vec{b}$ and $\overrightarrow{OC'} = \vec{a} - \vec{b}$ as shown in the figure.



From the figure,

$OA = |\vec{a}|$

$OB = AC = |\vec{b}|$

$OC = |\vec{a} + \vec{b}|$

$OC' = |\vec{a} - \vec{b}|$

(a) In a triangle, each side is smaller than the sum of other two sides.

So, in ΔAOC,

$OC < OA + AC$

$\Rightarrow |\vec{a} + \vec{b}| < |\vec{a}| + |\vec{b}|$

If both the vectors act along a straight line, then the equality condition occurs as

So, $|\vec{a} + \vec{b}| = |\vec{a}| + |\vec{b}|$

$\therefore |\vec{a} + \vec{b}| \le |\vec{a}| + |\vec{b}|$

(b) In ΔAOC,

$OC + AC > OA$

$\Rightarrow |OC| > |OA - AC|$

$\Rightarrow |OC| > |OA - OB|$ ($\because AC = OB$ are the parallel sides of the parallelogram)

$\Rightarrow |\vec{a} + \vec{b}| > ||\vec{a}| - |\vec{b}||$

If both the vectors act along a straight line, then the equality condition occurs as

$|\vec{a} + \vec{b}| = ||\vec{a}| - |\vec{b}||$

$\therefore |\vec{a} + \vec{b}| \ge ||\vec{a}| - |\vec{b}||$

(c) In $\Delta OAC'$,

$OC' < OA + AC'$

$\Rightarrow |\vec{a} - \vec{b}| < |\vec{a}| + |-\vec{b}|$

$\Rightarrow |\vec{a} - \vec{b}| < |\vec{a}| + |\vec{b}| \; (\therefore |-\vec{b}| = |\vec{b}|)$

If both the vectors act along a straight line, then the equality condition occurs as

$|\vec{a} - \vec{b}| = |\vec{a}| + |\vec{b}|$

$\therefore |\vec{a} - \vec{b}| \le |\vec{a}| + |\vec{b}|$

(d) In $\Delta OAC'$,

OC’ + AC’ > OA

⇒ |OC’|>|OA – AC’|

$\Rightarrow \left|\vec{a}-\vec{b}\right| > ||\vec{a}|-|-\vec{b}||$

$\Rightarrow \left|\vec{a}-\vec{b}\right| > ||\vec{a}|-|-\vec{b}||$

$\Rightarrow \left|\vec{a}-\vec{b}\right| > ||\vec{a}|-|\vec{b}||$

If both the vectors act along a straight line, then the equality condition occurs as

$\left|\vec{a}-\vec{b}\right| = ||\vec{a}|-|\vec{b}||$

$\Rightarrow \left|\vec{a}-\vec{b}\right| \geq ||\vec{a}|-|\vec{b}||$

NOTE: Parallelogram Law of Vector Addition states that when two vectors are represented by two adjacent sides of a parallelogram by direction and magnitude then the resultant of these vectors is represented in magnitude and direction by the diagonal of the parallelogram starting from the same point.

7. Given a + b + c + d = 0, which of the following statements are correct:

(a) a, b, c, and d must each be a null vector,

(b) The magnitude of (a + c) equals the magnitude of (b + d),

(c) The magnitude of a can never be greater than the sum of the magnitudes of b, c, and d,

(d) b + c must lie in the plane of a and d if a and d are not collinear, and in the line of a and d, if they are collinear?

7. **(a) Incorrect**

In order to make a + b + c + d = 0, it is not necessary to have all the four given vectors to be null vectors. There are many other combinations which can give the sum zero.

(b) Correct

a + b + c + d = 0 a + c = – (b + d)

Taking modulus on both the sides, we get:

| a + c | = | – (b + d) | = | b + d |

Hence, the magnitude of (a + c) is the same as the magnitude of (b + d).

(c) Correct

a + b + c + d = 0 a = (b + c + d)

Taking modulus both sides, we get:

| a | = | b + c + d |

|a| ≤ | a | + |b| + |c| .... (i)

Equation (i) shows that the magnitude of a is equal to or less than the sum of the magnitudes of b, c, and d.

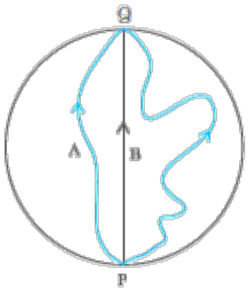
Hence, the magnitude of vector a can never be greater than the sum of the magnitudes of b, c, and d.

(d) Correct

For a + b + c + d = 0

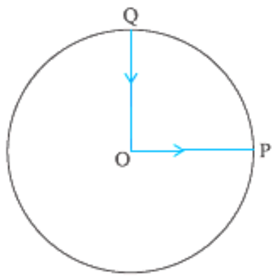
The resultant sum of the three vectors a, (b + c), and d can be zero only if (b + c) lie in a plane containing a and d, assuming that these three vectors are represented by the three sides of a triangle.
If a and d are collinear, then it implies that the vector (b + c) is in the line of a and d. This implication holds only then the vector sum of all the vectors will be zero.

8. Three girls skating on a circular ice ground of radius 200 m start from a point P on the edge of the ground and reach a point Q diametrically opposite to P following different paths as shown in figure. What is the magnitude of the displacement vector for each? For which girl is this equal to the actual length of the path skated?



8. Displacement of an object is given by the change in its position. Here, the initial position is P and the final position is Q for all three girls. So, the displacement is same for all the three girls and its magnitude is equal to the diameter of the circular ice ground.
So, Magnitude of Displacement = 2×Radius = 2×200m=400m. The magnitude of the displacement is equal to the actual path length travelled for girl B since she moved along the diameter.

9. A cyclist starts from the centre O of a circular park of radius 1 km, reaches the edge P of the park, then cycles along the circumference, and returns to the centre along QO as shown in figure. If the round trip takes 10 min, what is the (a) net displacement, (b) average velocity, and (c) average speed of the cyclist?



9. (a) Displacement is given by the minimum distance between the initial and final positions of a body. In the given case, the cyclist comes to the starting point after cycling for 10 minutes. Hence, his net displacement is zero.
(b) Average velocity is given by the relation:

$$\text{Average velocity} = \frac{\text{Net displacement}}{\text{Total time}}$$

Since the net displacement of the cyclist is zero, his average velocity will also be zero.
(c) Average speed of the cyclist is given by the relation:

$$\text{Average speed} = \frac{\text{Total path lenght}}{\text{Total time}}$$

Total path length = OP + PQ + QO = $1+\frac{1}{4}(2\pi\times 1)+1$

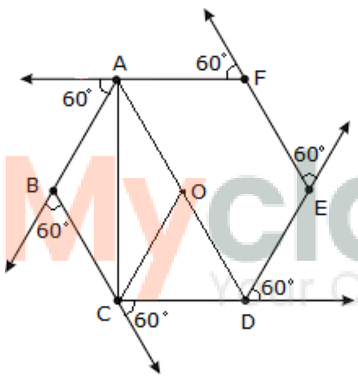
$$= 2+\frac{1}{2}\pi = 3.570\text{km}$$

Time taken = 10 min = $\frac{10}{60}=\frac{1}{6}\text{h}$

$$\therefore \text{Average speed} = \frac{3.570}{\frac{1}{6}} = 21.42 \text{ km/h}$$

10. On an open ground, a motorist follows a track that turns to his left by an angle of 60° after every 500 m. Starting from a given turn, specify the displacement of the motorist at the third, sixth and eighth turn. Compare the magnitude of the displacement with the total path length covered by the motorist in each case.

10. The entire motion of the motorist can be shown using the following diagram:



Let A be the starting point of the motorist.

<u>At the third turn:</u>

At the third turn, his position is D.

Magnitude of Displacement = AD

⇒ Magnitude of Displacement = AO + OD

⇒ Magnitude of Displacement = 500m + 500m

⇒ Magnitude of Displacement = 1000m

Total path length = AB + BC + CD

⇒ Total path length = 500m + 500m + 500m

⇒ Total path length = 1500m

<u>At the sixth turn:</u>

At the sixth turn, the position of the motorist is A.

So, the final position is the initial position i.e., there is no change in position.

Hence, magnitude of displacement = 0

Total path length = AB + BC + CD + DE + EF + FA

⇒ Total path length = 500m+500m+500m+500m+500m+500m

⇒ Total path length = 3000m

<u>At the eighth turn:</u>

At the eighth turn, the position of the motorist is C.

Magnitude of displacement = AC

$\Rightarrow$ Magnitude of displacement = $\sqrt{(AB)^2 + (BC)^2 + 2(AB)(BC)\cos 60°}$

$\Rightarrow$ Magnitude of displacement = $\sqrt{(500)^2 + (500)^2 + 2(500)(500)\cos 60°}$

$\Rightarrow$ Magnitude of displacement = $\sqrt{250000 + 250000 + \left(500000 \times \frac{1}{2}\right)}$

$\Rightarrow$ Magnitude of displacement = $\sqrt{750000}$

$\therefore$ Magnitude of displacement = 866.025m

Total path length = AB + BC

$\Rightarrow$ Total path length = 500m + 500m

$\therefore$ Total path length = 1000m

NOTE: Total path length or distance travelled is the length of the actual path taken by an object whereas displacement is the change in its position i.e., the shortest distance between the final position and the initial position. Path length is a scalar quantity whereas displacement is a vector quantity.