NCERT solutions for class 11 physics chapter 4 Motion in a Plane

Q. 4.1 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

Answer:

Volume is a **scalar quantity** since it has only magnitude without any direction.

Mass is a **scalar quantity** because it is specified only by magnitude.

Speed is specified only by its magnitude not by its direction so it is a **scalar quantity** .

Acceleration is a **vector quantity** as it has both magnitude and direction associated.

Density is a **scalar quantity** as it is specified only by its magnitude.

The number of moles is a **scalar quantity** as it is specified only by its magnitude.

Velocity is a **vector quantity** as it has both magnitude and direction.

Angular frequency is a **scalar quantity** as it is specified only by its magnitude.

Displacement is a **vector quantity** since it has both magnitude and associated direction.

Angular velocity is a **vector quantity** as it has both magnitude and direction.

Q. 4.2 Pick out the two scalar quantities in the following list :

force, angular momentum, work, current, linear momentum, electric field, average velocity, magnetic moment, relative velocity.

Answer:

The two scaler quantities are **work and current** , as these two don't follow laws of vector addition.

Q. 4.3 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.

Answer:

Among all, the **impulse** is the only vector quantity as it is the product of two vector quantities. Also, it has an associated direction.

Q. 4.4 (a) 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

Answer:

(a) Adding two scalars is meaningful if the two have the same unit or both represent the same physical quantity.

(b) Adding a scalar to a vector of the same dimensions is meaningless as vector quantity has associated direction.

(c) Multiplication of vector with scaler is meaningful as it just increases the magnitude of vector quantity and direction remains the same.

(d) Multiplication of scaler is valid and meaningful , unbounded of any condition. This is because, if we have two different physical quantity then their units will also get multiplied.

(e) Adding two vectors is meaningful if they represent the same physical quantity. This is because their magnitude will get added and direction will remain the same.

(f) Adding a component of a vector to the same vector is meaningful as this represents the same case of adding vectors with the same dimensions. In this, the magnitude of the resultant vector will increase and the direction will remain the same.

Q. 4.5 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 the 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.

Answer:

(a) True.

Since the magnitude of a vector will not have any direction (also it is a number), so it will be scaler.

(b) False.

The component of a vector will always be a vector as it will also have a direction specified.

(c) False.

This is true only in case when the particle is moving in a straight line. This is because path length is a scalar quantity whereas displacement is vector.

(d) True

From the above part (c) it is clear that total path length is either equal or greater than the displacement. As a result given statement is true.

(e) True

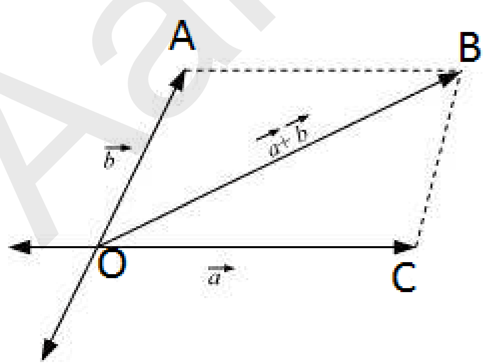
Since they don't lie in the same plane so they cannot give null vector after addition.

Q. 4.6 (a) Establish the following vector inequalities geometrically or otherwise :

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

Answer:

Consider the image given below :-



In Δ OCB,

$OB < OC + BC$

or $|a + b| < |a| + |b|$ ....(i)

But if $a \ and \ b$ are in a straight line
then $|a + b| \ = \ |a| \ + \ |b|$ ....(ii)

From (i) and (ii), we can conclude that,

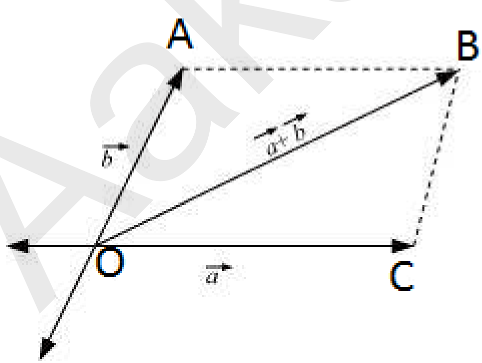
$|a + b| \leq |a| + |b|$

Q. 4.6 (b) Establish the following vector inequalities geometrically or otherwise :

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

Answer:

Consider the given image:



In $\triangle$ OCB, we have:

Sum of two sides of a triangle is greater than the length of another side.

or $OB + BC > OC$

or $OB > |OC - BC|$

or $|a + b| \ > \ | \ |a| - |b| \ |$ ....(i)

Also, if $a \ and \ b$ are in a straight line but in the opposite direction then

$|a + b| \ = \ | \ |a| - |b| \ |$ ....(ii)

From (i) and (ii), we get :

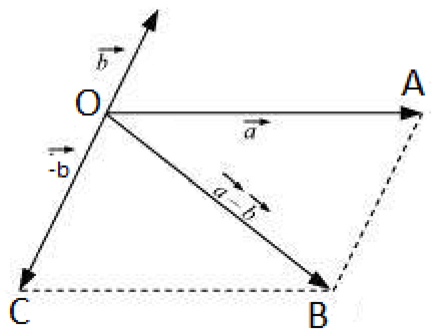
$|a + b| \geq | \ |a| - |b| \ |$

Q. 4.6 (c) Establish the following vector inequalities geometrically or otherwise :

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

Answer:

Consider the image given below:-



In $\triangle$ OAB, we have

$OB < OA + AB$

or $|a-b| \ < |a|+|b|$ ....(i)

For vectors in a straight line, $|a-b| \ = \ |a|+|b|$ ....(ii)

From (i) and (ii) we get :

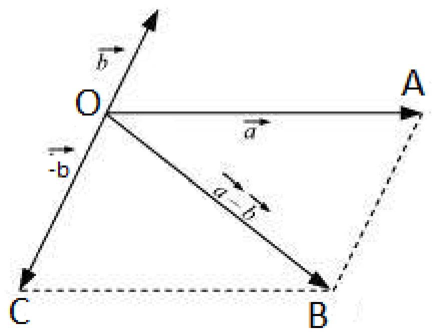
$|a-b| \leq |a|+|b|$

Q. 4.6 (d) Establish the following vector inequalities geometrically or otherwise :

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

Answer:

Consider the image given below :



In $\triangle$ OAB, we have :

$OB + AB > OA$

or $OB > |OA - AB|$

or $|a - b| > ||a| - |b||$ ....(i)

Also, if the vectors are in a straight line then :

$|a - b| = ||a| - |b||$ ....(ii)

From (i) and (ii), we can conclude :

$|a - b| \geq ||a| - |b||$

Q. 4.7 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?

Answer:

(a) **Incorrect:** - Sum of three vectors in a plane can be zero. So it is not a necessary condition that all of a,b,c,d should be null vector.

(b) **Correct** : We are given that a + b + c + d = 0

So, a + b = - (c + d)

Thus magnitude of a + c is equal to the c+d.

(c) **Correct** :- We have a + b + c + d = 0

b + c + d = - a

So clearly magnitude of a cannot be greater than the sum of the other three vectors.

(d) **Correct:** - Sum of three vectors is zero if they are coplanar.

Thus, a + b + c + d = 0

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

Hence (b+c) must be coplaner with a and d

Q. 4.8 Three girls skating on a circular ice ground of radius $200m$ 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 Fig. 4.20. What is the magnitude of the displacement vector for each? For which girl is this equal to the actual length of path skate?

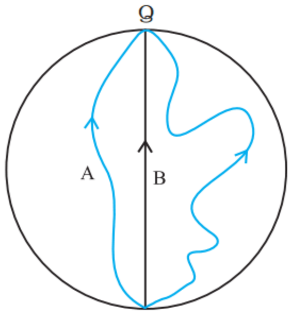


Fig. 4.20

Answer:

The displacement vector is defined as the shortest distance between two points which particle had covered.

In this case, the shortest distance between these points is the diameter of the circular ice ground.

Thus, Displacement = 400 m.

Girl B had travelled along the diameter so path travelled by her is equal to the displacement.

Q. 4.9 (a) 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 Fig. 4.21. If the round trip takes $10 min.$ what is the

(a) net displacement,

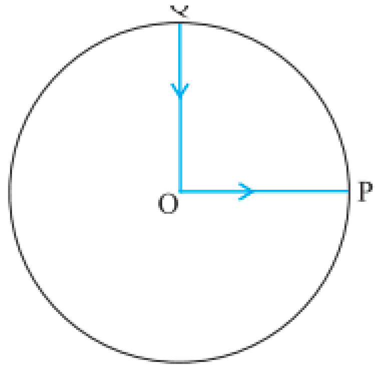


Fig. 4.21

Answer:

The net displacement, in this case, will be **zero** because the initial and final position is the same.

Net displacement = Final position - Initial position .

Q. 4.9 (b) 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 Fig. 4.21. If the round trip takes $10\ min.$ what is the

(b) average velocity,

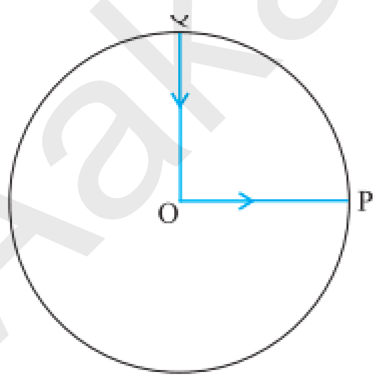


Fig. 4.21

Answer:

(b) Average velocity is defined as the net displacement per unit time. Since we have the net displacement to be zero so **the avg. velocity will also be zero** .

$$Avg.\ Velocity\ =\ \frac{Net\ displacement}{Time\ taken}$$

Q. 4.9 (c) 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 Fig. 4.21. If the round trip takes $10\ min.$ what is the

(c) the average speed of the cyclist?

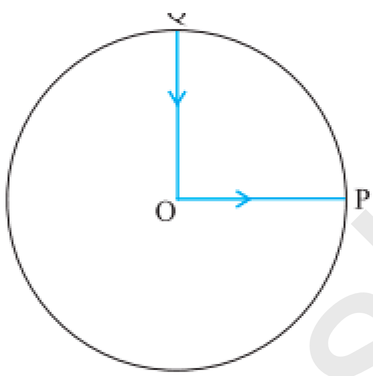


Fig. 4.21

Answer:

(c) For finding average speed we need to calculate the total path travelled.

Total path = OP + arc PQ + OQ

$$= 1 + \frac{1}{4}(2\Pi \times 1) + 1$$

$$= 3.57\ Km$$

$$Time\ taken\ in\ hour\ = \frac{1}{6}$$

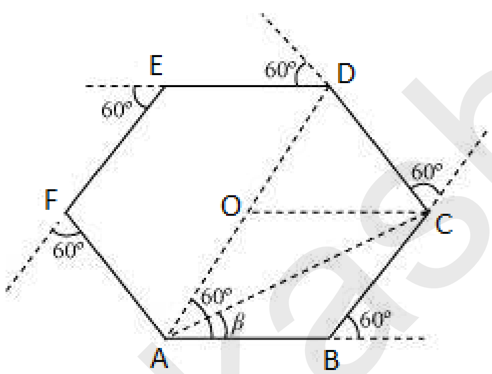
So the avg. speed is :

$$= \frac{3.57}{\frac{1}{6}}\ = \ 21.42\ Km/h$$

Q. 4.10 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.

Answer:

The track is shown in the figure given below:-



Let us assume that the trip starts at point A.

The third turn will be taken at D.

So displacement will be = Distance AD = 500 + 500 = 1000 m

Total path covered = AB + BC + CD = 500 + 500 + 500 = 1500 m

The sixth turn is at A.

So the displacement will be Zero

and total path covered will be = 6 (500) = 3000 m

The eighth turn will be at C.

So the displacement = AC

$= \sqrt{AB^2 + BC^2 + 2(AB)(BC)\cos 60^\circ}$

or $= \sqrt{(500)^2 + (500)^2 + 2(500)(500)\cos 60^\circ}$

$= 866.03\ m$

And the total distance covered = 3000 + 1000 = 4000 m=4Km

Q. 4.11 (a) A passenger arriving in a new town wishes to go from the station to a hotel located $10\ km$away on a straight road from the station. A dishonest cabman takes him along a circuitous path $23\ km$. long and reaches the hotel in $28\ min.$ What is

(a) the average speed of the taxi,

Answer:

(a) Avg. speed of taxi is given by:-

$= \dfrac{Total\ path\ travelled}{Total\ time\ taken}$

$$= \frac{23\ Km}{\frac{28}{60}\ h}$$

$$= 49.29\ Km/h$$

Q. 4.11 (b) A passenger arriving in a new town wishes to go from the station to a hotel located $10\ km$, away on a straight road from the station. A dishonest cabman takes him along a circuitous path $23\ km$. long and reaches the hotel in $28\ min.$ What is

(b) the magnitude of average velocity? Are the two equal?

Answer:

Total displacement = 10 Km

Total time taken in hours :

$$= \frac{28}{60}\ hr$$

Avg. velocity **:**

$$= \frac{10}{\frac{28}{60}}\ hr$$

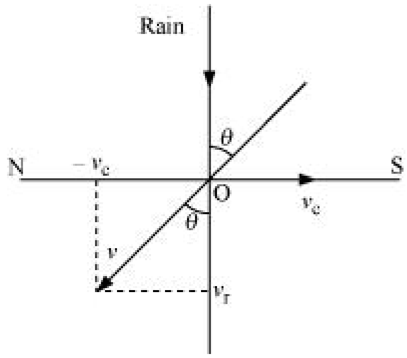
$$= 21.43\ Km/h$$

It can be clearly seen that avg. speed and avg. velocity is not the same.

Q. 4.12 Rain is falling vertically with a speed of $30\ ms^{-1}$ A woman rides a bicycle with a speed of $10\ ms^{-1}$. in the north to south direction. What is the direction in which she should hold her umbrella?

Answer:

The given situation is shown in the figure:-



Since both rain and woman are having some velocity so we need to find the relative velocity of rain with respect to woman.

$$V = V_{rain} + (-V_{woman})$$

$$= 30 + (-10)$$

$$= 20\ m/s$$

And the angle is given by :

$$\tan \Theta = \frac{V_{woman}}{V_{rain}}$$

$$\tan \Theta = \frac{10}{30}$$

$$\Theta \approx 18^{\circ}$$

Hence woman needs to hold an umbrella at 18 degrees from vertical towards the south.

Q. 4.13 A man can swim with a speed of $4.0\ km/h$ in still water. How long does he take to cross a river $1.0\ km/h$ wide if the river flows steadily at $3.0\ km/h$ and he makes his strokes normal to the river current? How far down the river does he go when he reaches the other bank?

Answer:

The speed of man is (swim speed) = 4 Km/h.

Time taken to cross the river will be :

$$= \frac{Distance}{Speed}$$

$$= \frac{1}{4} = 15\ min.$$

Total distance covered due to the flow of the river:-

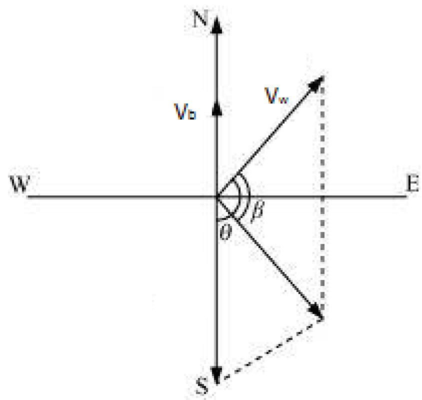
$$= Speed\ of\ river \times Time\ taken$$

$$= 3 \times \frac{1}{4} = 0.75\ Km$$

Q. 4.14 In a harbour, wind is blowing at the speed of $72\ km/h$ and the flag on the mast of a boat anchored in the harbour flutters along the N-E direction. If the boat starts moving at a speed of $51\ km/h$ to the north, what is the direction of the flag on the mast of the boat?

Answer:

According to the question the figure is shown below:-



The angle between velocity of wind and opposite of velocity of boat is (90 + 45) = 135 degree.

Using geometry,

$$\tan\beta = \frac{51\sin(90+45)}{72 + 51\cos(90+45)}$$

$$\tan\beta = \frac{51}{50.8}$$

Thus $\beta = \tan^{-1}\frac{51}{50.8}$

$$= 45.11^\circ$$

So the flag will be just 0.11 degree from the perfect east direction.

Q. 4.15 The ceiling of a long hall is $25\ m$ high. What is the maximum horizontal distance that a ball thrown with a speed of $40\ m\ s^{-1}$ can go without hitting the ceiling of the hall?

Answer:

It is known that the maximum height reached by a particle in projectile motion is given by :

$$h = \frac{u^2 sin^2\Theta}{2g}$$

Putting the given values in the above equation :

$$25 = \frac{40^2 sin^2\Theta}{2 \times 9.8}$$

So, we get

$\sin\Theta = 0.5534$ and $\Theta = 33.60^\circ$

Now the horizontal range can be found from :

$$R = \frac{U^2 \sin 2\Theta}{g}$$

or $= \dfrac{40^2 \sin(2 \times 33.6)}{9.8}$

$= 150.53\ m$

Q. 4.16 A cricketer can throw a ball to a maximum horizontal distance of $100\ m$. How much high above the ground can the cricketer throw the same ball?

Answer:

We are given the range of projectile motion.

$$R = \frac{u^2\ \sin 2\Theta}{g}$$

Substituting values :

$$100 = \frac{u^2\ \sin 90^\circ}{g}$$

So, $\frac{u^2}{g} = 100$

Now since deacceleration is also acting on the ball in the downward direction :

$v^2 - u^2 = -2gh$

Since final velocity is 0, so maximum height is given by :

$H = \frac{u^2}{2g}$

or $H = 50\ m$

Q. 4.17 A stone tied to the end of a string $80\ cm$ long is whirled in a horizontal circle with a constant speed. If the stone makes 14 revolutions in $25\ s,$, what is the magnitude and direction of acceleration of the stone?

Answer:

Frequency is given by :

$Frequency = \frac{No.\ of\ revolutions}{Total\ time\ taken}$

$= \frac{14}{25}\ Hz$

And, the angular frequency is given by :

$\omega = 2\Pi f$

Thus, $= 2 \times \frac{22}{7} \times \frac{14}{25}$

$= \dfrac{88}{25}\ rad/s$

Hence the acceleration is given by :

$a\ =\ \omega^2 r$

or $=\ \left(\dfrac{88}{25}\right)^2 \times 0.8$

or $a\ =\ 9.91\ m/s$

Q. 4.18 An aircraft executes a horizontal loop of radius $1.00\ km$ with a steady speed of $900\ km/h$.Compare its centripetal acceleration with the acceleration due to gravity.

Answer:

Convert all the physical quantities in SI units.

$Speed\ =\ 900 \times \dfrac{5}{18}\ 250\ m/s$

So the acceleration is given by :

$a\ =\ \dfrac{v^2}{r}$

$=\ \dfrac{(250)^2}{1000}$

$=\ 62.5\ m/s^2$

The ratio of centripetal acceleration with gravity gives :

$\dfrac{a}{g} = \ \dfrac{62.5}{9.8}\ =\ 6.38$

Q. 4.19 (a) Read each statement below carefully and state, with reasons, if it is true or false :

(a) The net acceleration of a particle in circular motion is always along the radius of the circle towards the centre

Answer:

False :- Since the net acceleration is not directed only along the radius of the circle. It also has a tangential component.

Q. 4.19 (b) Read each statement below carefully and state, with reasons, if it is true or false :

(b) The velocity vector of a particle at a point is always along the tangent to the path of the particle at that point

Answer:

True: - Because particle moves on the circumference of the circle, thus at any its direction should be tangential in order to move in a circular orbit.

Q. 4.19 (c) Read each statement below carefully and state, with reasons, if it is true or false :

(c) The acceleration vector of a particle in uniform circular motion averaged over one cycle is a null vector

Answer:

True: - In a uniform circular motion, acceleration is radially outward all along the circular path. So in 1 complete revolution, all the vectors are cancelled and the null vector is obtained.

Motion in a Plane Excercise:

Question:

Q. 4.20 (a) The position of a particle is given by $r = 3.0t\ \hat{i} - 2.0t^2\ \hat{j} + 4.0\ \hat{k}\ m$ where t is in seconds and the coefficients have the proper units for r to be in metres.

(a) Find the v and a of the particle?

Answer:

(a) We are given the position vector $r = 3.0t\ \hat{i} - 2.0t^2\ \hat{j} + 4.0\ \hat{k}\ m$

The velocity vector is given by:-

$$v \ = \ \frac{dr}{dt}$$

$$v \ = \ \frac{d\left(3.0t\ \hat{i} - 2.0t^2\ \hat{j} + 4.0\ \hat{k}\right)}{dt}$$

or $v \ = \ 3\ \hat{i} - 4t\ \hat{j}$

Now for acceleration :

$$a \ = \ \frac{dv}{dt}$$

$$= \ d(\frac{3\ \hat{i} - 4t\ \hat{j})}{dt}$$

$$= \ -4\ \hat{j}$$

Q. 4.20 (b) The position of a particle is given by $r = 3.0t\ \hat{i} - 2.0t^2\ \hat{j} + 4.0\ \hat{k}\ m$ where t is in seconds and the coefficients have the proper units for r to be in metres.

(b) What is the magnitude and direction of velocity of the particle at $t = 2.0\ s$?

Answer:

Put the value of time t = 2 in the velocity vector as given below :

$v\ =\ 3\,\hat{i} - 4t\,\hat{j}$

or $v\ =\ 3\,\hat{i} - 4(2)\,\hat{j}$

or $=\ 3\,\hat{i} - 8\,\hat{j}$

Thus the magnitude of velocity is :

$=\ \sqrt{3^2\ +\ (-8)^2}\ =\ 8.54\ m/s$

Direction :

$\Theta\ =\ \tan^{-1}\frac{8}{3}\ =\ -69.45^\circ$

Q. 4.21 (a) A particle starts from the origin at $t\ =\ 0\ s$ with a velocity of $10.0\ \hat{j}\ m/s$ and moves in the x-y plane with a constant acceleration of $\left(8.0\ \hat{i} + 2.0\ \hat{j}\right)m\ s^{-2}$.

(a) At what time is the x- coordinate of the particle $16\ m$? What is the y-coordinate of the particle at that time

Answer:

We are given the velocity of the particle as $10.0\ \hat{j}\ m/s$.

And the acceleration is given as :

$$\left(8.0\,\hat{i}+2.0\,\hat{j}\right)m\,s^{-2}$$

So, the velocity due to acceleration will be :

$$a = \frac{dv}{dt}$$

So, $dv = \left(8.0\,\widehat{i} + 2.0\,\widehat{j}\right)dt$

By integrating both sides,

or $v = 8.0t\,\widehat{i} + 2.0t\,\widehat{j} + u$

Here u is the initial velocity (at t = 0 sec).

Now,

$$v = \frac{dr}{dt}$$

or $dr = \left(8.0t\,\widehat{i} + 2.0t\,\widehat{j} + u\right)dt$

Integrating both sides, we get

$$r = 8.0 \times \frac{1}{2}t^2\,\widehat{i} + 2.0 \times \frac{1}{2}t^2\,\widehat{j} + (10t\,)\widehat{j}$$

or $r = 4t^2\,\widehat{i} + (t^2 + 10t\,)\widehat{j}$

or $x\widehat{i} + y\widehat{j} = 4t^2\,\widehat{i} + (t^2 + 10t\,)\widehat{j}$

Comparing coefficients, we get :

$x = 4t^2$ and $y = 10t + t^2$

In the question, we are given x = 16.

So t = 2 sec

and y = 10 (2) + 2 ^{2} = 24 m.

Q. 4.21 (b) A particle starts from the origin at $t = 0\ s$ with a velocity of $10.0\ \hat{j}\ m/s$ and moves in the x-y plane with a constant acceleration of $\left(8.0\ \hat{i} + 2.0\ \hat{j}\right) m\ s^{-2}$.

(b) What is the speed of the particle at the time?

Answer:

The velocity of the particle is given by :

$v = 8.0t\ \widehat{i} + 2.0t\ \widehat{j} + u$

Put t = 2 sec,

So velocity becomes :

$v = 8.0(2)\ \widehat{i} + 2.0(2)\ \widehat{j} + 10\widehat{j}$

or $v = 16\ \widehat{i} + 14\ \widehat{j}$

Now, the magnitude of velocity gives :

$|v| = \sqrt{16^2 + 14^2}$

$= \sqrt{256 + 196}$

$= \ 21.26 \ m/s$

Q 4. 22 $\hat{i}$ and $\hat{j}$ are unit vectors along x- and y- axis respectively. What is the magnitude and direction of the vectors $\hat{i} + \hat{j}$, and $\hat{i} - \hat{j}$? What are the components of a vector $A = 2\hat{i} + 3\hat{j}$ along the directions of $\hat{i} + \hat{j}$ and $\hat{i} - \hat{j}$? [You may use graphical method]

Answer:

Let A be a vector such that:- $\overrightarrow{A} \ = \ \widehat{i} \ + \ \widehat{j}$

Then the magnitude of vector A is given by : $|A| \ = \ \sqrt{1^2 \ + \ 1^2} \ = \ \sqrt{2}$

Now let us assume that the angle made between vector A and x-axis is Θ .

Then we have:-

$$\Theta \ = \ \tan^{-1}\left(\frac{1}{1}\right) \ = \ 45^{\circ}$$

Similarly, let B be a vector such that:- $\overrightarrow{B} \ = \ \widehat{i} \ - \ \widehat{j}$

The magnitude of vector B is : $|B| \ = \ \sqrt{1^2 \ + \ (-1)^2} \ = \ \sqrt{2}$

Let α be the angle between vector B and x-axis :

$$\alpha \ = \ \tan^{-1}\left(\frac{-1}{1}\right) \ = \ -45^{\circ}$$

Now consider $\overrightarrow{C} = 2\hat{i} + 3\hat{j}$:-

Then the required components of a vector C along the directions of $(\hat{i} + \hat{j})$ is:- $= \frac{2+3}{\sqrt{2}} = \frac{5}{\sqrt{2}}$

and the required components of a vector C along the directions of $(\hat{i} - \hat{j})$ is:- $\frac{2-3}{\sqrt{2}} = \frac{-1}{\sqrt{2}}$

Q. 4.23 For any arbitrary motion in space, which of the following relations are true :

(a) $v_{average} = (1/2)\,[v\,(t_1) + v\,(t_2)]$

(b) $v_{average} = [r\,(t_2) - r\,(t_1)]\,/\,(t_2 - t_1)$

(c) $v(t) = v\,(0) + a\ t$

(d) $v(t) = r\,(0) + v\,(0)\,t + (1/2)\,a\,t^2$

(e) $a_{average} = [v(t_2) - v(t_1)]\,/\,(t_2 - t_1)$

Answer:

(a) False:- Since it is arbitrary motion so the following relation cannot hold all the arbitrary relations.

(b) True:- This is true as this relation relates displacement with time correctly.

(c) False: - The given equation is valid only in case of uniform acceleration motion.

(d) False:- The given equation is valid only in case of uniform acceleration motion. But this is arbitrary motion so acceleration can be no-uniform.

(e) True:- This is the universal relation between acceleration and velocity-time, as the definition of acceleration is given by this.

Q. 4.24 Read each statement below carefully and state, with reasons and examples, if it is true or false :

A scalar quantity is one that

(a) is conserved in a process

(b) can never take negative values

(c) must be dimensionless

(d) does not vary from one point to another in space (e) has the same value for observers with different orientations of axe

Answer:

(a) False:- For e.g. energy is a scalar quantity but is not conserved in inelastic collisions.

(b) False:- For example temperature can take negative values in degree Celsius.

(c) False:- Since speed is a scalar quantity but has dimensions.

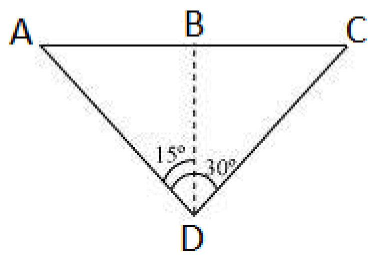
(d) False:- Gravitational potential varies in space from point to point.

(e) True:- Since it doesn't have direction.

Q. 4.25 An aircraft is flying at a height of $3400\ m$ above the ground. If the angle subtended at a ground observation point by the aircraft positions $10.0\ s$ apart is 30°, what is the speed of the aircraft?

Answer:

The given situation is shown in the figure:-



For finding the speed of aircraft we just need to find the distance AC as we are given t = 10 sec.

Consider $\triangle$ ABD,

$$\tan 15^\circ = \frac{AB}{BD}$$

$$AB = BD \times \tan 15^\circ$$

or $AC = 2AB = 2BD \times \tan 15^\circ$

or $= 2 \times 3400 \times \tan 15^\circ$

or $= 1822.4\ m$

Thus, the speed of aircraft :

$$= \frac{1822.4}{10} = 182.24\ m/s$$

NCERT solutions for class 11 physics chapter 4 motion in a plane additional exercise

Q. 4.26 A vector has magnitude and direction. Does it have a location in space? Can it vary with time? Will two equal vectors a and b at different locations in space necessarily have identical physical effects ? Give examples in support of your answer

Answer:

No, a vector doesn't have a definite location as a vector can be shifted in a plane by maintaining its magnitude and direction.

Vector can change with time for e.g. displacement vector.

No, two equal vectors at a different location may not have identical physical effects. For e.g., two equal force vectors at a different location may have different torque but when they are applied together the net torque would be different.

Q. 4.27 A vector has both magnitude and direction. Does it mean that anything that has magnitude and direction is necessarily a vector? The rotation of a body can be specified by the direction of the axis of rotation, and the angle of rotation about the axis. Does that make any rotation a vector?

Answer:

The main condition for a physical quantity to be a vector is that it should the law of vector addition. Also, the vector has both direction and, magnitude but these are not sufficient condition. For e.g. current has both magnitude and direction but is a scalar quantity as it doesn't follow the law of vector addition.

Rotation is not a vector on a large basis, as it is measured by an angle which follows the law of scaler addition.

Q. 4.28 (a) Can you associate vectors with (a) the length of a wire bent into a loop, Explain.

Answer:

No, the length of a wire bent into a loop cannot be expressed in vector form as we have no direction associated with it.

Q. 4.28 (b) Can you associate vectors with (b) a plane area, Explain.

Answer:

(b) The plane area can be expressed in vector form as direction can be associated as pointing outward or inward (normal to the plane) of the area.

Q. 4.28 (c) Can you associate vectors with (c) a sphere? Explain.

Answer:

No, vector cannot be associated with a sphere as direction cannot be associated with sphere anyhow.

Q. 4.29 A bullet fired at an angle of 30° with the horizontal hits the ground $3.0\ km$ away. By adjusting its angle of projection, can one hope to hit a target $5.0\ km$ away? Assume the muzzle speed to be fixed, and neglect air resistance.

Answer:

The range of bullet is given to be:- R = 3 Km.

$$R = \frac{u^2 \sin 2\Theta}{g}$$

or $3 = \frac{u^2 \sin 60^\circ}{g}$

or $\frac{u^2}{g} = 2\sqrt{3}$

Now, we will find the maximum range (maximum range occurs when the angle of projection is 45 ^{0}).

$$R_{max} = \frac{u^2 \sin 2(45^\circ)}{g}$$

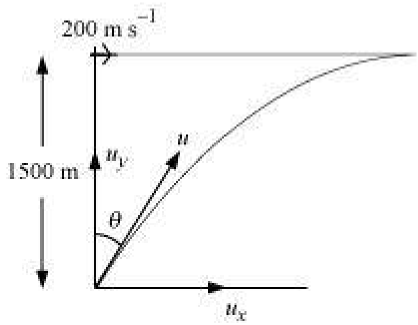
or = $3.46\ Km$

Thus the bullet cannot travel up to 5 Km.

Q. 4.30 A fighter plane flying horizontally at an altitude of $1.5\ km$ with speed $720\ km/h$ passes directly overhead an anti-aircraft gun. At what angle from the vertical should the gun be fired for the shell with muzzle speed $600\ m\ \ s^{-1}$ to hit the plane ? At what minimum altitude should the pilot fly the plane to avoid being hit? $(Take\ g = 10\ m\ s^{-2})$.

Answer:

According to the question the situation is shown below:-



Now, the horizontal distance travelled by the shell = Distance travelled by plane

or $u \sin \Theta \ t \ = \ vt$

or $\sin \Theta \ = \ \frac{v}{u}$

or $= \ \frac{200}{600}$

So, $\Theta \ = \ 19.5^\circ$

So, the required height will be:-

$$H \ = \ \frac{u^2 \ \sin^2(90 \ - \ \Theta)}{2g}$$

or $= \ \frac{600^2 \ \cos^2 \Theta}{2g}$

or $= \ 16006.48 \ m$

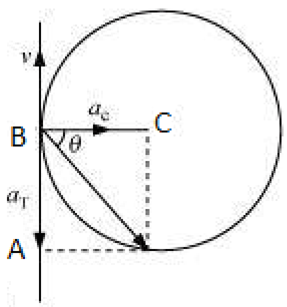
or $= \ 16 \ Km$

Q. 4.31 A cyclist is riding with a speed of $27 \ km/h.$ As he approaches a circular turn on the road of radius $80 \ m,$ he applies brakes and reduces his speed at the constant rate of $0.50\ m/s$ every second. What is the magnitude and direction of the net acceleration of the cyclist on the circular turn?

Answer:

Speed of cycle = 27 Km/h = 7.5 m/s

The situation is shown in figure :-



The centripetal acceleration is given by :

$$a_c = \frac{v^2}{r}$$

$$= \frac{(7.5)^2}{80}$$

$$= 0.7\ m/s^2$$

And the tangential acceleration is given as $0.5\ m/s^2$.

So, the net acceleration becomes :

$$a = \sqrt{a_c^2 + a_T^2}$$

or $= \sqrt{(0.7)^2 + (0.5)^2}$

or $= 0.86\ m/s^2$

Now for direction,

$\tan\Theta = \frac{a_c}{a_T}$

or $= \frac{0.7}{0.5}$

Thus, $\Theta = 54.46°$

Q. 4.32 (a) Show that for a projectile the angle between the velocity and the x-axis as a function of time is given by $\theta(t) = tan^{-1}\left[\frac{v_{0y-gt}}{v_{0x}}\right]$

where the symbols have their usual meaning.

Answer:

Using the equation of motion in both horizontal and vertical direction.

$v_y = v_{oy} = gt$ and $v_x = v_{ox}$

Now,

$\tan\Theta = \frac{v_y}{v_x}$

or $= \frac{v_{oy} - gt}{v_{ox}}$

Thus, $\Theta = \tan^{-1}\left(\frac{v_{oy} - gt}{v_{ox}}\right)$

Q. 4.32 (b) Shows that the projection angle θ_0 for a projectile launched from the origin is given by

$$\theta_0 = tan^{-1}\left[\frac{4h_m}{R}\right]$$

where the symbols have their usual meaning.

Answer:

(b) The maximum height is given by :

$$h = \frac{u^2 \sin^2 \Theta}{2g}$$

And, the horizontal range is given by :

$$R = \frac{u^2 \sin 2\Theta}{g}$$

Dividing both, we get :

$$\frac{h}{R} = \frac{\tan \Theta}{4}$$

Hence $\Theta = \tan^{-1}\left(\frac{4h}{R}\right)$