Motion in a plane

2 Marks Answers and Questions

Q1. Name two quantities that are the largest when the maximum height attained by the projectile is the largest.

Ans. The two quantities that are found to be the largest when a maximum **height** is attained by a projectile are Time of flight and the vertical component of **velocity**.

Q2. Can a particle accelerate when its speed is constant? Explain.

Ans. Yes. A particle can surely go through **acceleration** even though its speed is constant. A particle that has a **uniform circular motion** has a constant speed, however, its direction of motion continuously changes. This creates a change in velocity and the particle now moves with variable velocity. This is how the particle is accelerating.

Q3. (a) Is circular motion possible at a constant speed or constant velocity? Explain.

(b) Define frequency and time.

Ans. (a) Circular motion can happen even at a constant speed. This is because, in a circular motion, speed remains constant, however, the motion's direction continuously keeps changing.

(b) **Frequency** is known as the number of rotations completed by a body in one second and the time is known as the time taken to complete one rotation by an object.

Q4. When vector A's component along the direction of vector B's component is zero, what can you understand about both of these vectors?

Ans. The two vectors that are A and B are found to be perpendicular to each other.

This can be explained as follows: Let θ = angle between the two vectors A and B component of vector A along the direction of B is obtained by resolving A i.e. A cos θ.

As the statement says

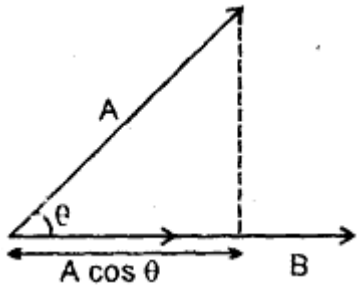
$A \cos\theta = 0$

or

$\cos\theta = 0 = \cos 90°$

$\theta = 90°$

i.e. $A \perp B$



Hence proved.

Q5. Comment on the statement whether it is true or false "Displacement vector is fundamentally a position vector.'' Why?

Ans. The statement given above is true. The **displacement vector** and **position vector** both give the position of a point. The only difference between both of these vectors is that the displacement vector gives the point's position with reference to a point that is not only the origin, while the position vector provides a point's position with the origin's reference.

Q6. A stone tied at the end of the string is whirled in a circle. State the reason why the stone flies away tangentially when the string breaks.

Ans: When a stone is tied at the end of a string that moves in a circular path, its velocity is tangent to the circle. The centripetal force does not work when the string breaks. The stone moves along the tangent to the circular path and flies away tangentially due to inertia.

Q7. What does "uniform circular motion" mean? What do you mean by the terms 'time period', 'frequency', and 'angular velocity'? Explain the relationship between them.

Ans: The motion is considered to be a uniform circular motion when an object rotates in a circular path with the same speed.

The total time taken by the object to complete one revolution is considered a time period.

The total number of revolutions completed per second is termed "frequency."

The angular velocity is defined as the time rate of transformation of angular displacement.

=2T=2

1T=, which is the required relation.

4 Marks Answers and Questions

Q1. a)Define time of flight and horizontal range?

Ans: The time of flight is the time required by the projectile to finish its trajectory.

The horizontal range is the maximum horizontal distance travelled by the projectile from the bottom of the tower to the point the projectile touches the ground.

b) From a certain height above the ground, stone A is gently dropped. Simultaneously, another stone, B, is fired horizontally. Which of the two stones will touch the ground first?

Ans: Because the initial vertical velocity in both scenarios is zero, and the stones fall with a similar acceleration equal to gravity's acceleration. Therefore, both stones will simultaneously touch the ground.

Q2. The ceiling of a long hall is 25m high. What is the maximum horizontal distance that a ball thrown with a speed of 40m/s can go without hitting the ceiling of the hall?

Ans. Given that,

Speed of the ball is given as, =40m/s

Maximum height is given as, h=25m

In projectile motion, the maximum height attained by a body projected at an angle , is given by the formula:

h=u2sin22g

25=40229.8

sin2=0.30625

sin=0.5534

=sin-1(0.5534)=33.60°

Horizontal Range,

R=u2sin2g

R=402 sin2(33.60)9.8

R=1600 sin(67.2)9.8

R=1600 0.9229.8=150.53m

Q3. Derive expressions for velocity and acceleration for uniform circular motion.

Ans. We can write,

If PQ=l,

V=lt

And angular velocity can be given as

=l

Using, =lr,

=lr …….(1)

l=Vt and =t

Substituting in (1)

t=V tr

V=r, which is the required expression for velocity.

Also,

a=dVdt=rddt=drdt=V=VrV=V2r

a=V2r, which is the required expression for acceleration.

Q4. Explain linear motion.

Ans. one-dimensional motion across a straight line that uses only one spatial dimension is considered to be a linear motion. This motion is also called a rectilinear motion. Uniform linear motion with a constant velocity and zero acceleration and non-uniform linear motion with a variable velocity and non-zero acceleration are the two most evident types of linear motion. It is the most basic of all the motions. Linear motion is considered to be nearly similar to general motion. The rolling of the ball on the ground is an example of linear motion.

Q5. A passenger arriving in a new town wants to go from the station to a hotel located 10km away on a straight road from the station. A dishonest cabman takes him along a circuitous path 23km long and reaches the hotel in 28 min. (a) What is the average speed of the taxi? (b) What is the magnitude of average velocity? Are the two equal?

Ans. (a) Total distance travelled =23km

Total time taken = 28 min=2860h

Therefore,

Average speed =Total distance travelled Total time taken

=23286049.29km/h

(b) Distance between the hotel and the station =10km= Displacement of the car

Therefore,

Average velocity =102860=21.34km/h

The two physical quantities are not equal.

Q6. After carefully reading each statement below and providing appropriate reasons, state whether it is true or false.

(a) The acceleration vector of a particle in uniform circular motion averaged over one cycle is a null vector.
(b) The net acceleration of a particle in a circular motion is always along the radius of the circle towards the centre.
(c) The velocity vector of a particle at a point is always along the tangent to the path of the particle at that point.

(a) True

The acceleration vector direction faces toward the centre of the circle in a uniform circular motion. Later, it frequently changes with time, and over one cycle, the average of these vectors is a null vector.

(b) False

In a uniform circular motion, a particle's net acceleration in circular motion is always guided across the radius of the circle, pointing to the centre.

(c) True

A particle visibly moves tangentially at a point on a circular path.

6. A passenger arriving in a new town wishes to go from the station to a hotel located 1010 km away on a straight road from the station. A dishonest cabman takes him along a circuitous path 23km23 long and reaches the hotel in 28min28min. What is

a) The average speed of the taxi?

Ans: Given that,

Total distance travelled can be given as =23km=23

Total time taken can be given as

$$=28\text{min}=28/60\ \text{h}$$

$$\text{Averagespeedofthetaxi}=\text{Totaldistancetravelled}/\text{Totaltimetaken}$$

$$\Rightarrow\text{Averagespeedofthetaxi}=23(2860)=49.29\text{km/h}\Rightarrow h=23(2860)=49.29/h$$

b) The magnitude of average velocity? Are they two equal?

Ans: Given that,

Distance between the hotel and the station

=10km=10

Displacement of the car.

Averagevelocity=10(2860)=21.43km/h10(2860)=21.43 h

Therefore, the two physical quantities (average speed and average velocity) are unequal.

7 Marks Answers and Questions

Q1. A particle starts from the origin at t=0s with a velocity of 10 ĵm/s and moves in the x-y plane with a constant acceleration of 8î+2ĵm/s2.

1. **a) At what time is the x-coordinate of the particle** 16m**? What is the y-coordinate of the particle at that time?**

Ans. The velocity of the particle is given as =10 ĵm/s

Acceleration of the particle is given as **a=ddt=8î+2ĵ**

Also, **a=8î+2ĵ**

But,

a=ddt=8î+2ĵ

d=8î+2ĵdt

Integrating both sides:

(t)=**8tî+2tĵ+u**

Where,

= Velocity vector of the particle at t = 0

u= Velocity vector of the particle at time t

However,

=**drdt**

=dt=(8tî+2tĵ+u)dt

Integrating the equations with the conditions: at t=0; r=0 and at t=t; and

r=r

r=ut+128t2î+122t2ĵ

r=ut+4t2î+t2ĵ

=(10ĵ)t+4t2î+t2ĵ

x**î+y**ĵ**=4t2î+(10t+t2)**ĵ

Since the motion of the particle is confined to the x-y plane, on equating the coefficients of **î** and **ĵ** we get,

x=4**t2**

t=x412

And y=10t+t2

When x=16m:

t=16412=2s, which is the required time.

y=102+22=24m, which is the required y coordinate.

1. **b) What is the speed of the particle at the time?**

Ans: Velocity of the particle can be given by:

(t)=**8tî+2tj+u**

At t=2s

(2)=**8(2)î+2(2)ĵ+10ĵ**

=**16î+14ĵ**

=**162+142**

=**256+196**

=**452**

=**21.26m/s,** which is the required speed.

Q2.

a) What is the angle between A□**and** B□**. If** A□**and** B□**denote the adjacent sides of a parallelogram drawn from a point and the area of the parallelogram is** 1/2AB**?**

Ans: Area of a parallelogram can be given as

=| A□ ×B□|

Area of parallelogram can be given as

=ABsinθ(Applying cross product)

Given data is,
Area of parallelogram

$$=12AB=12$$

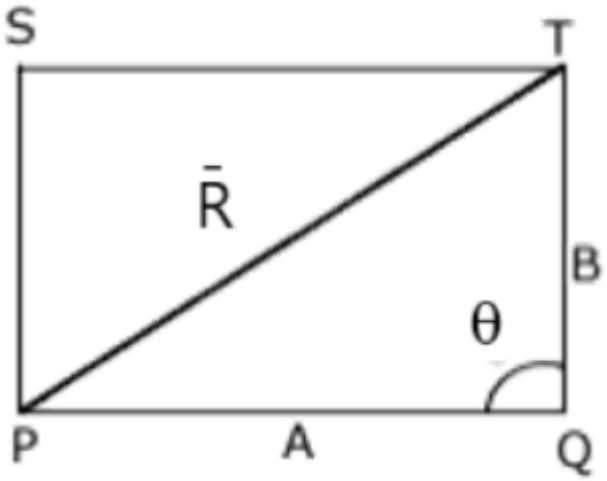
So,

$$12=AB=AB\sin\theta 12$$

$$\Rightarrow 12=\sin\theta \Rightarrow 12$$

$$\Rightarrow \theta=\sin-1(12) \Rightarrow =\sin-1(12)$$

$$\Rightarrow \theta=30\circ \Rightarrow =30\circ$$



Clearly, area of a parallelogram can be given as

$$=| | A\square \times B\square | |$$

Q3. A cyclist rides at a speed of 27km/h. As he is approaching a circular turn that is on the road with a radius of 80m, he applied his brakes and reduced his speed at a constant rate of 0.5m/s each second. What will be the direction and magnitude and the net acceleration of the cyclist when he is on the circular turn?

Ans. Speed of the cyclist is given as, v = 27 km/h = 7.5 m/s

Radius of the turn that is circular, r = 80 m

Centripetal acceleration can be given as ac = v2/r

⇒ ac = (7.5)2/80 = 0.7m/s

Now, Let us suppose the cyclist begins cycling from point P and moves toward point Q. At point Q, he applies the brakes and decelerates the speed of the bicycle by

0.5 m/s2.

This acceleration is found to be along the tangent at Q and the direction of motion of the cyclist's opposite direction.

Because the angle between ac and at is 90â, the resultant acceleration a is given by:

a = √ac2 + at2

⟹a = √00.72 + 0.52

⟹a = √0.74 = 0.86 m/s2

⟹a= √0.740.74= 0.86 m/s2

tanθ= ac/at

Where θ becomes the angle of the resultant with velocity's direction.

tanθ= 0.7/0.5 =1.4

⇒ θ = tan−1(1.4)

⇒ θ = 54.460, which is the required angle of direction here.

Q4. Ten one-rupee coins are put on top of each other on a table. Each coin has a mass m. Give the magnitude and direction of

(a) the force on the 7th coin (counted from the bottom) due to all the coins on its top,

(b) the force on the 7th coin by the 8th coin,

(c) the reaction of the sixth coin on the seventh coin.

Ans. (a) The Force on the 7th coin is exerted by the three coins' weight on its top.

- Weight of 1 coin = mg
- Weight of 3 coins = 3mg

Hence, the force exerted on the 7th coin by the 3 coins on its top is 3mg. This force acts vertically downward.

(b) The Force on the 7th coin by the 8th coin is because of the weight of the 8th coin and the other 2 coins (9th and 10th) on its top.

- Weight of the 8th coin = mg
- Weight of the 9th coin = mg
- Weight of the 10th coin = mg
- Total weight of these 3 coins = 3mg

Hence, the total force exerted on the seventh coin by the eighth coin is 3mg. This force acts vertically downward.

(c) The 6th coin experiences a downward force because of the weight of the 4 coins (7th, 8th, 9th, and 10th) on its top.

Therefore, the downward force in total experienced by the sixth coin is 4mg.

In accordance with Newton"s third law of motion, the 6th coin will produce an equal reaction force on the 7th coin, but in the opposite direction. Therefore the reaction force of the 6th coin on the 7th coin is of magnitude 4mg. This force acts in the upward direction.

Q5. A man of mass of 70 kg stands on a weighing scale in a lift which is moving

(a) upwards along with a uniform speed of 10m/s

(b) downwards along with a uniform acceleration of 5 m/s

(c) upwards with a uniform acceleration of 5m/s2.

What would be the readings on the scale in each case?

(d) Calculate what would be the reading if the lift mechanism failed and it hurtled down freely under gravity?

Ans. (a) The Mass of the given man is m = 70 kg

Acceleration that is a = 0

In accordance with **Newton"s second law of motion**, we shall write the equation of motion as follows:

R - mg = ma

Where ma is the net force that is acting on the man.

As the lift is found to be moving at a uniform speed, acceleration is a = 0

∴ R = mg

= 70 × 10 = 700 N

∴ The reading on the weighing scale will be 700/g = 700/10 = 70 kg

(b) Mass of the given man is m = 70 kg

Acceleration, a = 5 m/s2 downward

Using Newton"s second law of motion, we can write the equation of motion as:

R + mg = ma

= R = m (g - a)

= 70 (10 - 5) = 70 x 5

= 350 N

∴ The Reading on the weighing scale is found to be = 350/g = 350/10 = 35 kg

(c) Mass of the given man, m = 70 kg

The Acceleration, a = 5m/s2 upward

By Using Newton"s second law of motion, we shall write the equation of motion as:

R - mg = ma

R = m (g + a)

= 70 (10 + 5) = 70 × 15

= 1050 N

∴ The Reading on the weighing scale is found to be = 1050/g = 1050/10 = 105 kg

(d) The acceleration is a = g, as the lift moves freely under gravity.

In accordance with Newton"s second law of motion, we shall write the equation of motion as:

R + mg = ma

R = m (g - a)

= m (g - g) = 0

∴ Reading on the weighing scale = 0/g = 0kg

The man will be found in a state of weightlessness.

Multiple Choice Questions

Q.1. Which of the following conditions are sufficient and essential for a quantity to be a vector?
(a) Magnitude and direction
(b) Magnitude and addition, subtraction, multiplication by ordinary rules of algebra

(c) Magnitude, direction, and addition, subtraction multiplication and division by vector laws
(d) Magnitude, direction and combination of vectors by ordinary rules of algebra

Answer:(c) Magnitude, direction, and addition, subtraction multiplication and division by vector laws

Q.2. A scalar quantity is one that
(a) can never take negative values
(b) has magnitude as well as direction
(c) does not vary from one point to another in space
(d) has the same value for observers with different orientations of axes.

Answer:(d) has the same value for observers with different orientations of axes.

Q.3. If T is the angle between two vectors, then the resultant vector is maximum, when value of T is
(a) 0°
(b) 90°
(c) 180°
(d) Same in all cases.

Answer: (a) 0°

Q.4. When a body moves with a constant speed along a circle
(a) no work is done on it
(b) no acceleration is produced in the body
(c) no force acts on the body
(d) its velocity remains constant

Answer:(a) no work is done on it

Q.5. A body is travelling in a circle at a constant speed. It
(a) has a constant velocity
(b) is not accelerated
(c) has an inward radial acceleration
(d) has an outward radial acceleration

Answer:(c) has an inward radial acceleration

Q.6. How many minimum number of vectors in different planes can be added to give zero resultant?
(a) 2
(b) 3
(c) 4
(d) 5

Answer: (c) The resultant of any three vectors will be cancel out by Fourth vector

Q.7. Consider the quantities pressure, power, energy, impulse, gravitational potential, electric charge, temperature and area. Out of these, the vector quantities are
(a) impulse, pressure and area
(b) impulse and area
(c) area and gravitational potential
(d) impulse and pressure

Answer: (b)impulse and area

Q.8. Angular momentum is
(a) a scalar
(b) a polar vector
(c) an axial vector
(d) None of these

Answer:(c) an axial vector

Q.9. The shape of trajectory of the motion of an object is determined by
(a) acceleration
(b) initial position

(c) initial velocity
(d) All of these

Answer: (d) The shape of the trajectory depends on the initial position, initial velocity and acceleration.

Q.10. If a particle moves in a circle describing equal angles in equal interval of time, its velocity vector
(a) remains constant
(b) changes in magnitude
(c) changes in direction
(d) changes both in magnitude and direction
Answer:(c) changes in direction

Q.11. Which of the following is an essential condition for horizontal component of projectile to remain constant?

(a) Acceleration due to gravity should be exactly constant
(b) Angle of projection should be 45°
(c) There should be no air-resistance
(d) All of these

Answer: (c) Force due to viscosity, air – resistance are all dissipative forces. Thus in the presence of air – resistance the horizontal component of velocity will decrease, thus for horizontal component of velocity to remain constant, there should be no air-resistance

Fill in the blanks

1. **The magnitude of the resultant of two vectors is ……When they act in the same direction and is …….. When they act in opposite direction.**

Answer: The magnitude of the resultant of two vectors is maximum When they act in the same direction and is minimum When they act in opposite direction.

2. **The rotation of a body is a scalar quantity…….. .**

Answer:The rotation of a body is a scalar quantity is finite.

3. **The maximum height attained by a projectile is equal to……..of its maximum range.**

Answer:The maximum height attained by a projectile is equal to one-forth of its maximum range.

4. **The path of an object moving with uniform velocity in two dimension is a ……..line .**

Answer:The path of an object moving with uniform velocity in two dimension is a straight line .

5.Tangential acceleration acts along the …… to the circular path and is ……. To the centripetal acceleration .

Answer:Tangential acceleration acts along the tangent to the circular path and is perpendicular To the centripetal acceleration .

6.When a body is moving with a constant angular velocity , its angular acceleration is…… .

Answer: When a body is moving with a constant angular velocity , its angular acceleration is zero .

7.The centripetal force ……..increase the kinetic energy of a particle moving in a circular path .

Answer:The centripetal force cannot increase the kinetic energy of a particle moving in a circular path .