Important Questions for Class 11 Physics Chapter 3: Class 11 Physics Chapter 3, Motion in a Plane, focuses on the motion of objects in two dimensions. Key topics include vector representation, displacement, velocity, and acceleration in the plane, along with projectile motion.

Students are introduced to concepts like relative velocity, uniform circular motion, and the use of kinematic equations in two dimensions. Important questions often involve calculating the components of motion, analyzing projectile trajectories, and solving problems related to centripetal acceleration. Understanding vector addition, resolving forces, and applying principles to real-life scenarios are central to mastering this chapter.

Important Questions for Class 11 Physics Chapter 3 Overview

Chapter 3 of Class 11 Physics, Motion in a Plane, explores the fundamental concepts of vector analysis, projectile motion, and circular motion. Key topics include the resolution of vectors, relative velocity, and motion under uniform circular motion, which are crucial for understanding real-world applications like satellite orbits, sports trajectories, and vehicles on curved paths.

Mastery of this chapter lays the foundation for advanced topics in Physics, especially in mechanics. Important questions from this chapter test comprehension of vector addition, the laws of motion in two dimensions, and kinematic equations, making it essential for both board exams and competitive tests.

Important Questions for Class 11 Physics Chapter 3 Motion in a Plane

Below is the Important Questions for Class 11 Physics Chapter 3 Motion in a Plane -

1. What is the trajectory of a projectile?

Ans: Trajectory of a projectile can be defined as the path followed by a projectile. The trajectory may be of various forms, for example, parabola.

2. A projectile is fired at an angle of 30 with the horizontal with velocity $10m/s$. At what angle with the vertical should it be fired to get maximum range?

Ans: The maximum range that can be achieved is at an angle of 45.

3. What is the value of angular speed for 1 revolution?

Ans: For one complete revolution, $\theta = 2\pi$ in time period $t = T$, the angular speed can be given as $\omega = \frac{2\pi}{T}$.

4. Give an example of a body moving with uniform speed but having a variable velocity and an acceleration which remains constant in magnitude but changes in direction

Ans: An example of a body moving with uniform speed having velocity that is not constant can be given as a body moving in a circular path.

5. What is the direction of centripetal force when particle is following a circular path?

Ans: The direction of the centripetal force in a circular path is towards the centre of the circle.

6. Two vectors $\vec{A}$ and $\vec{B}$ are perpendicular to each other. What is the value of $\vec{A} \cdot \vec{B}$?

Ans: We know, $\theta = 90^\circ$

$\vec{A} \cdot \vec{B} = AB\cos\theta$

$\Rightarrow \vec{A} \cdot \vec{B} = 0$

7. What will be the effect on horizontal range of a projectile when its initial velocity is doubled, keeping the angle of projection same?

Ans: The horizontal range will be four times the initial horizontal range.

8. What will be the effect on the maximum height of a projectile when its angle of projection is changed from 30 to 60, keeping the same initial velocity of projection?

Ans: The maximum height will be three times the initial vertical height.

2 Marks Questions

1. What is the angle between two forces of $2N$ and $3N$ having resultant as $4N$?

Ans: Using the equation $R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$

We can write,

$\Rightarrow 4 = \sqrt{2^2 + 3^2 + 2 \times 2 \times 3\cos\theta}$

$\Rightarrow 16 = 4 + 9 + 12\cos\theta$

$\Rightarrow \cos\theta = \dfrac{3}{12} = \cos^{-1}0.25$

$\Rightarrow \theta = 75^\circ 32'$, which is the required angle.

2. What is the angle of projection at which horizontal range and maximum height are equal?

Ans: We can write,

$\dfrac{u^2\sin 2\theta}{g} = \dfrac{u^2\sin^2\theta}{2g}$

$\because \dfrac{u^2\sin 2\theta}{g} = R\,(Horizontal\,Range)$

Therefore, we can write,

$\sin 2\theta = \dfrac{1}{2}\sin^2\theta$

$\because \dfrac{u^2\sin^2\theta}{2g} = H_{\max}\,(Maximum\,Height)$

$\Rightarrow 2\sin\theta\cos\theta = \dfrac{1}{2}\sin^2\theta$

$\Rightarrow \tan\theta = 4$

$\Rightarrow \theta = 75.96^\circ$, which is the required angle of projection.

3. Prove that for elevations that exceed or fall short of 45° by equal amounts the ranges are equal.

Ans: We know that,

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

And,

$$\theta_1 = 45^\circ + \alpha$$

$$\theta_2 = 45^\circ - \alpha$$

$$R_1 = \frac{u^2 \sin 2\theta_1}{g} = \frac{u^2 \sin 2\left(45^\circ + \alpha\right)}{g}$$

$$\Rightarrow R_1 = \frac{u^2 \sin(90^\circ + 2\alpha)}{g}$$

And,

$$R_2 = \frac{u^2 \sin 2\theta_2}{g} = \frac{u^2 \sin 2\left(45^\circ - \alpha\right)}{g}$$

$$\Rightarrow R_2 = \frac{u^2 \sin(90^\circ - 2\alpha)}{g}$$

Therefore, we can write, $R_1 = R_2$.

4. At what range will a radar set show a fighter plane flying at $3km$ above its centre and at a distance of $4km$ from it?

Ans: Here, the straight distance of the object from the radar can be given as $= OB$

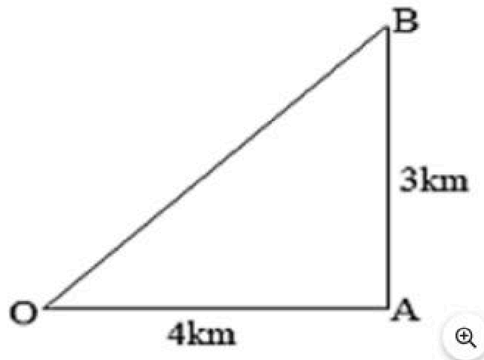
$$OB = \sqrt{4^2 + 3^2}$$

$$\Rightarrow OB = \sqrt{16 + 9}$$

$$\Rightarrow OB = \sqrt{25}$$

$$\Rightarrow OB = 5$$

$$\Rightarrow Range = 5km$$



5. Two forces $5kg\,wt$ and $10kg\,wt$ are acting with an inclination of 120° between them. What is the angle which the resultant makes with $10kg\,wt$?

Ans: We can write,

$$F_1 = 5kg\,wt$$
$$F_2 = 10kg\,wt$$
$$\Rightarrow F = \sqrt{{F_1}^2 + {F_2}^2 + 2F_1F_2\cos\theta}$$
$$\tan\beta = \frac{F_2\sin\theta}{F_1 + F_2\cos\theta}$$
$$\Rightarrow \tan\beta = \frac{5\sin 120^\circ}{10 + 5\cos 120^\circ}$$
$$\Rightarrow \tan\beta = \frac{5 \times \frac{\sqrt{3}}{2}}{10 - 5 \times \frac{1}{2}}$$
$$\Rightarrow \tan\beta = \frac{1}{\sqrt{3}}$$
$\Rightarrow \beta = \tan^{-1}\left(\frac{1}{\sqrt{3}}\right) = 30^\circ$, which is the required angle here.

6. A stone is thrown vertically upwards and then it returns to the thrower. Is it a projectile? Explain.

Ans: A stone thrown vertically upwards cannot be called as a projectile since a projectile must have two perpendicular components of velocities but in the given case a stone has velocity in one direction while going up or coming downwards.

7. Which is greater: the angular velocity of the hour hand of a watch or angular velocity of the eartl around its own axis?

Ans: In hour hand of a watch time period can be given as $T = \frac{1}{2}h$

$$\omega_H = \frac{2\pi}{12}$$

For rotation of earth can be given as $T = 24h$

$$\omega_E = \frac{2\pi}{24}$$

$$\Rightarrow \frac{\omega_H}{\omega_E} = \frac{24}{12} = 2$$

$$\Rightarrow \omega_H = 2\omega_E$$

Clearly, $\omega_H > \omega_E$.

8. Why does the direction of motion of a projectile become horizontal at the highest point of its trajectory?

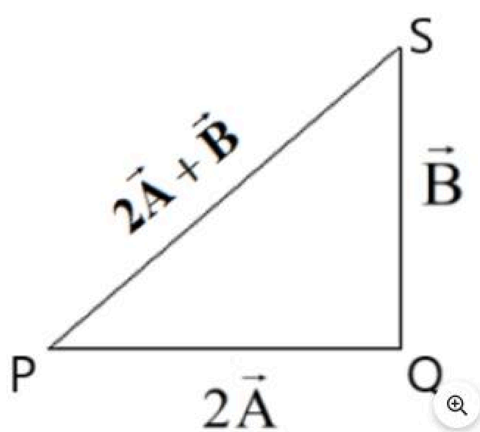
Ans: At the highest point of the trajectory, the vertical component of velocity becomes zero. Thus, the direction of motion of the projectile becomes horizontal.

9. A vector $\vec{A}$ has magnitude 2 and another vector $\vec{B}$ have magnitude 3 and is perpendicular to each other. By vector diagram, find the magnitude of $2\vec{A} + \vec{B}$ and show its direction in the diagram.

Ans: We can write,

$$\overrightarrow{PQ} = 2\vec{A} = 4cm; \overrightarrow{QS} = \vec{B} = 3cm$$

$$\left|\overrightarrow{PS}\right| = \sqrt{PQ^2 + QS^2} \Rightarrow \left|\overrightarrow{PS}\right| = \sqrt{4^2 + 3^2} \Rightarrow \left|\overrightarrow{PS}\right| = 5cm$$



10. Find a unit vector parallel to the resultant of the vectors $\vec{A} = 2\hat{i} + 3\hat{j} + 4\hat{k}$ and $\vec{B} = 3\hat{i} + 5\hat{j} + \hat{k}$.

Ans: We know that $\hat{R} = \frac{\vec{R}}{|\vec{R}|}$

$\vec{R} = \vec{A} + \vec{B} = \left(2\hat{i} + 3\hat{j} + 4\hat{k}\right) + \left(3\hat{i} + 5\hat{j} + \hat{k}\right)$

$\Rightarrow \vec{R} = 5\hat{i} - 2\hat{j} + 5\hat{k}$

$\Rightarrow \left|\vec{R}\right| = \sqrt{5^2 + (-2)^2 + 5^2}$

$\Rightarrow \left|\vec{R}\right| = \sqrt{25 + 4 + 25}$

$\Rightarrow \left|\vec{R}\right| = \sqrt{54}$

$\Rightarrow \hat{R} = \frac{5\hat{i} - 2\hat{j} + 5\hat{k}}{\sqrt{54}}$, which is the required unit vector.

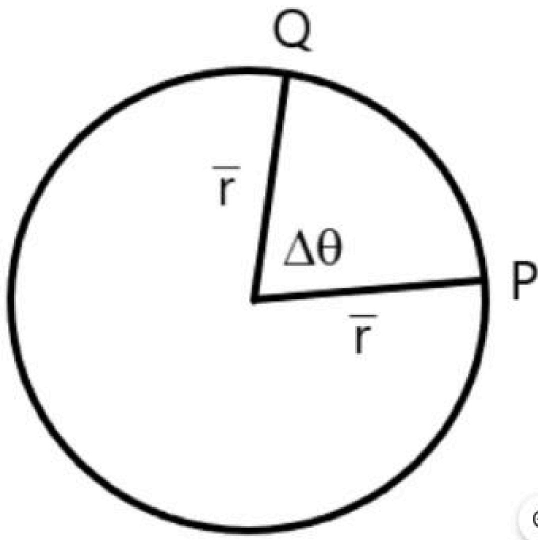
11. A stone tied at the end of string is whirled in a circle. If the string breaks, the stone flies away tangentially. Why?

Ans: When a stone, that is tied at the endpoint of a string, moving around a circular path, its velocity acts tangent to the circle.

When the string breaks, the centripetal force will not act. Because of inertia, the stone continues to move along the tangent to the circular path and flies off tangentially to the circular path.

3 Marks Questions

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



Ans: We can write,

If $PQ = \Delta l$,

$$V = \frac{\Delta l}{\Delta t}$$

And angular velocity can be given as $\omega = \frac{\Delta \theta}{\Delta l}$

Using $\theta = \frac{l}{r} \Rightarrow \Delta \theta = \frac{\Delta l}{r}$...... (1)

$\Delta l = V \Delta t$ and $\Delta \theta = \omega \Delta t$

Substituting in (1)

$$\omega \Delta t = V \frac{\Delta t}{r}$$

$\Rightarrow V = r\omega$, which is the required expression for velocity.

Also,

$$a = \frac{dV}{dt} = r\frac{d\omega}{dt} = \omega\frac{dr}{dt} = \omega V = \frac{V}{r} \times V = \frac{V^2}{r}$$

$\Rightarrow a = \frac{V^2}{r}$, which is the required expression for acceleration.

2. Derive an equation for the path of a projectile fired parallel to horizontal.

Ans: Let a projectile having initial uniform horizontal velocity u be under the influence of gravity, then at any instant t at position P the horizontal and vertical.

For horizontal motion

$$s = ut + \frac{1}{2}at^2$$

$s = x$, $u = u$, $t = t$, $a = 0$

$$x = ut$$

$$\Rightarrow t = \frac{x}{u} \text{ ...... (1)}$$

For vertical motion,

$$s = ut + \frac{1}{2}at^2$$

$s = -y$, $u = 0$, $t = t$, $a = -g$

$$-y = -\frac{1}{2}gt^2$$

$$\Rightarrow y = \frac{1}{2}gt^2 \text{ ...... (2)}$$

Using equation (1) and (2)

$\Rightarrow y = \frac{1}{2}g\left(\frac{x}{u}\right)^2 = \frac{1}{2}g\frac{x^2}{u^2}$, which is the required equation of the path.

3. a) Define time of flight and horizontal range.

Ans: The time taken by the projectile to complete its trajectory is defined as time of flight.

The maximum horizontal distance covered by the projectile from the foot of the tower to the point where projectile hits the ground is defined as horizontal range.

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

Ans: Both the stones will reach the ground simultaneously since the initial vertical velocity in both cases is zero and both are falling with same acceleration equal to acceleration due to gravity.

4. At what point of projectile motion

a) Potential energy is the maximum?

Ans: P.E. will be maximum at the highest point(H).

$$(P.E.)_{Highest\ Point} = mgH$$

$$\Rightarrow (P.E.)_H = mg\left(\frac{u^2\sin^2\theta}{2g}\right) \Rightarrow (P.E.)_H = \frac{1}{2}mu^2\sin^2\theta$$

b) Kinetic energy is the minimum?

Ans: K.E will be minimum at the highest point. i.e.,

$$(K.E.)_H = \frac{1}{2}m(v_H)^2$$

Here, vertical component of velocity is zero.

$$\Rightarrow (K.E.)_H = \frac{1}{2}mv^2\cos^2\theta$$

c) Total mechanical energy is the maximum?

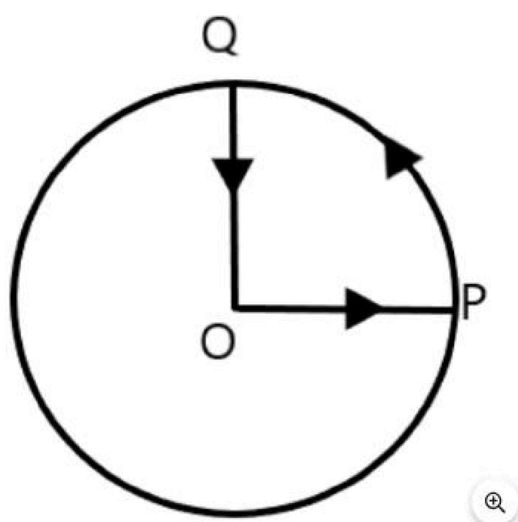
Ans: Total energy at any point of projectile motion will be the same. Mathematically, at the highest point;

$$(K.E.)_H + (P.E.)_H = \frac{1}{2}mv^2\cos^2\theta + \frac{1}{2}mu^2\sin^2\theta$$

$$\Rightarrow (K.E.)_H + (P.E.)_H = \frac{1}{2}mv^2\left(\cos^2\theta + \sin^2\theta\right)$$

$$\Rightarrow (K.E.)_H + (P.E.)_H = \frac{1}{2}mv^2$$

5. A cyclist starts from the centre O of a circular park of radius $1km$, 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 10min, what is the



a) Net displacement?

Ans: Displacement is given by the shortest distance between the initial and final positions of a body which is travelling. In the provided case, the cyclist comes to the starting point after cycling for 10minutes. Therefore, his net displacement is zero.

b) Average velocity?

Ans: Average velocity is given by the relation:

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

Because the net displacement of the cyclist is zero, his average velocity will also be zero.

c) Average speed of the cyclist?

Ans: Average speed of the cyclist is given by the formula:

$$Average\,speed = \frac{Total\,path\,length}{Total\,time}$$

Total path length is given as $= OP + PQ + QO$

$$\Rightarrow 1 + \frac{1}{4}(2\pi \times 1) + 1$$

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

Time taken can be given as $10\,\text{min} = \frac{10}{60} = \frac{1}{6}h$

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

6. A passenger arriving in a new town wishes 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 $28\,\text{min}$. What is

a) The average speed of the taxi?

Ans: Given that,

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

Total time taken can be given as $= 28\,\text{min} = \frac{28}{60}h$

$$Average\,speed\,of\,the\,taxi = \frac{Total\,distance\,travelled}{Total\,time\,taken}$$

$$\Rightarrow Average\,speed\,of\,the\,taxi = \frac{23}{\left(\frac{28}{60}\right)} = 49.29km/h$$

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

Ans: Given that,

Distance between the hotel and the station $= 10km =$ Displacement of the car.

$$Average\,velocity = \frac{10}{\left(\frac{28}{60}\right)} = 21.43km/h$$

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

4 Marks Questions

1. 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.

Ans: Incorrect.

To make $a+b+c+d=0$, it is not important to have all the four given vectors to be null vectors. There are many other combinations which can give the addition of vectors as zero.

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

Ans: Correct.

$a+b+c+d=0$

$a+c=-(b+d)$Taking modulus on both the sides, we obtain:

$|a+c|=|-(b+d)|=|b+d|$

Therefore, the magnitude of $a+c$ is the same as 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.

Ans: Correct.

$a+b+c+d=0$

$a=b+c+d$

Taking modulus on both sides, we obtain:

$|a|=|b+c+d|$

$|a|\leq|b|+|c|+|d|$ ...... (1)

Equation (1) shows that the magnitude of $a$is equal to or less than the sum of the magnitude of b, c, and d.

Therefore, the magnitude of vector $a$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.

Ans: Correct.

For $a+b+c+d=0$

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

The resultant sum of the three vectors a, $(b+c)$, and $d$is equal to 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 statement holds only when the vector sum of all the vectors will be zero.

2. In a harbour, wind is blowing at the speed of $72km/h$ 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 $51km/h$ to the north, what is the direction of the flag on the mast of the boat?

Ans: Velocity of the boat is given as $v_b=51km/h$

Velocity of the wind is given as $v_w=72km/h$

The flag is fluttering in the north-east direction. It means that the wind is blowing toward the north-east direction. When the ship starts sailing toward the north, the flag will move along the direction of the relative velocity (v_{wb}) of the wind with respect to the boat.

The angle between v_w and $(-v_b) = 90^\circ + 45^\circ$.

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

$$\Rightarrow \tan\beta = \frac{51\sin(45)^\circ}{72 + 51\left(-\cos 45^\circ\right)} = \frac{51 \times \frac{1}{\sqrt{2}}}{72 - 51 \times \frac{1}{\sqrt{2}}}$$

$$\Rightarrow \tan\beta = \frac{51}{72\sqrt{2} - 51} = \frac{51}{72 \times 1.414 - 51} = \frac{51}{50.800}$$

$$\Rightarrow \beta = \tan^{-1}(1.0038) = 45.11^\circ$$

Angle with respect to the east direction $= 45.11^\circ - 45^\circ = 0.11^\circ$.

Therefore, the flag will flutter almost due east.

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

Ans: Height of the fighter plane is given as $1.5km = 1500m$.

Speed of the fighter plane is given as, v = 720 km/h = 200 m/s

Let θ be the angle with the vertical so that the shell hits the plane. The situation is depicted in the given figure.

Muzzle velocity of the gun, $u = 600 m/s$
Time taken by the shell to hit the plane $= t$
Horizontal distance travelled by the shell $= u_x t$
Distance travelled by the plane $= vt$
The shell hits the plane. Therefore, these two distances should be equal.

$$u_x t = vt$$
$$u \sin\theta = v$$
$$\sin\theta = \frac{v}{u}$$
$$\Rightarrow \sin\theta = \frac{200}{600} = \frac{1}{3} = 0.33$$
$$\theta = \sin^{-1}(0.33)$$
$$\Rightarrow \theta = 19.5^\circ$$

In order to avoid being hit by the shell, the pilot must fly the plane at an altitude (H) higher than the maximum height achieved by the shell.

$$H = \frac{u^2 \sin^2(90 - \theta)}{2g}$$
$$\Rightarrow H = \frac{(600)^2 \cos^2\theta}{2g}$$
$$\Rightarrow H = \frac{360000 \times \cos^2 19.5}{2 \times 10}$$
$$\Rightarrow H = 18000 \times (0.943)^2$$
$$\Rightarrow H = 16006.42 m$$

$\Rightarrow H = 16 km$, which is the required height.

Benefits of Using Important Questions for Class 11 Physics Chapter 3

Using important questions for Class 11 Physics Chapter 3 "Motion in a Plane" offers several benefits for students:

Focused Learning: Important questions help students focus on key concepts, formulas, and applications. They ensure that students cover all essential topics while preparing for exams.

Better Concept Clarity: By practicing important questions, students can reinforce their understanding of crucial concepts like projectile motion, relative velocity, and circular motion, which are central to the chapter.

Time Management: Important questions allow students to prioritize their study time, concentrating on topics that are more likely to appear in exams and helping them utilize their time more efficiently.

Improved Problem-Solving Skills: Working through challenging questions sharpens problem-solving abilities, which are critical for mastering physics. It enables students to apply theoretical knowledge to real-world scenarios.

Boosts Confidence: As students practice and solve important questions, they build confidence in their ability to tackle the exam. Familiarity with common question types reduces exam anxiety.

Exam Preparation: These questions give students an idea of the exam pattern and the type of questions they are likely to face, helping them prepare effectively.