Class 11 Physics · Chapter 3: Motion in a Plane

Answer key and marking scheme · 20 marks · about 40 minutes · based on NCERT

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1. For an object moving in a plane, the angle between its velocity and its acceleration [1]

(a) can only be 0° or 180°
(b) must always be 90°
(c) can have any value from 0° to 180°
(d) must always be less than 90°

Answer: (c) Only in one dimension are velocity and acceleration along one line. In two or three dimensions the angle between them may be anything from 0° to 180°.

2. A cyclist rides round a circular track at a steady speed. Her acceleration is [1]

(a) of constant magnitude, always directed towards the centre, so it is not a constant vector
(b) zero, because her speed does not change
(c) a constant vector directed towards the centre
(d) directed along the tangent to the track

Answer: (a) The velocity keeps changing direction, so there is an acceleration, v^2/R, towards the centre. Its magnitude is constant but its direction turns with her, so it is not a constant vector.

3. A disc rotates about its axis with constant angular speed. Points A and B are 5 cm and 15 cm from the axis. The ratio of their linear speeds $v_A : v_B$ is [1]

(a) 3 : 1
(b) 1 : 9
(c) 1 : 1
(d) 1 : 3

Answer: (d) Every point of the disc has the same ω, and $v = R\omega$, so $v_A : v_B = 5 : 15 = 1 : 3$. 1 : 1 would be the ratio of angular speeds; 1 : 9 wrongly squares the ratio of the radii.

4. If $A = 2\hat{i} + 3\hat{j}$ and $B = -5\hat{i} + \hat{j}$, the magnitude of A + B is [1]

(a) 7
(b) √53
(c) 5
(d) √17

Answer: (c) $R_x = 2 + (-5) = -3$, $R_y = 3 + 1 = 4$, so $|R| = \sqrt{(9 + 16)} = 5$. √53 is |A − B|, and 7 adds the magnitudes of the components.

5. Vector P has magnitude 5 units and points due north. Vector Q has magnitude 5 units and points north-east. Which statement is correct? [1]

(a) P = Q, since their magnitudes are equal
(b) P ≠ Q, since their directions differ
(c) P = Q, provided both are drawn from the same origin
(d) P and Q cannot be compared, since they act at different points

Answer: (b) Two vectors are equal only if they have the same magnitude and the same direction. P and Q have equal magnitudes but different directions, so P ≠ Q.

6. The hour hand of a wall clock is 4 cm long and its minute hand is 6 cm long. Find the ratio of the angular speeds, and of the linear speeds of their tips (minute hand : hour hand). [2]

$T_{minute} = 1$ h and $T_{hour} = 12$ h, and $\omega = 2\pi/T$, so ω_m : ω_h = 12 : 1. $v = R\omega$, so $v_m : v_h = (6 \times 12) : (4 \times 1) = 72 : 4 = 18 : 1$.

- ω ratio 12 : 1 from the periods (1)
- $v = R\omega$ gives 18 : 1 (1)

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7. A student uses $r = r_0 + v_0 t + \tfrac{1}{2}at^2$ to find where a stone whirled in a horizontal circle at constant speed will be after 3 s. Explain why the method fails. [2]

The equation holds only for a constant acceleration vector. In uniform circular motion the acceleration has constant magnitude v^2/R but always points to the centre, so its direction changes continuously. The acceleration is not constant, and the equation does not apply.

- equation needs a constant acceleration vector (1)
- centripetal acceleration changes direction, so it is not constant (1)

8. A scooter moves with a constant velocity of 5 m s^{-1} due north. This velocity vector is multiplied by a time interval of 4 s. State the magnitude, the direction and the physical quantity of the new vector. [2]

Multiplying a vector by a positive scalar changes its magnitude by that factor and keeps its direction: 5 m s^{-1} × 4 s = 20 m, due north. Its dimension is $[LT^{-1}][T] = [L]$: it is the displacement of the scooter in 4 s.

- 20 m, due north (1)
- identifies it as a displacement, dimension [L] (1)

9. A toy boat on a pond starts from the origin with velocity $3\hat{j}$ m s^{-1}, and a steady breeze gives it a constant acceleration $2\hat{i}$ m s^{-2}. Find the equation of its path, name the curve, and find its speed at t = 2 s. [3]

$x = \tfrac{1}{2} \times 2 \times t^2 = t^2$, $y = 3t$. Eliminating t: $x = y^2/9$, a parabola (its axis along x). At t = 2 s, $v = 2t\,\hat{i} + 3\hat{j} = 4\hat{i} + 3\hat{j}$, speed $\sqrt{(16 + 9)} = 5$ m s^{-1}.

- $x = t^2$, $y = 3t$ (1)
- $x = y^2/9$, a parabola (1)
- speed 5 m s^{-1} at t = 2 s (1)

10. The resultant of two forces P and Q is 17 N when they act in the same direction and 13 N when they act at right angles. Find P and Q, and the resultant when the angle between them is 60°. [3]

Same direction: $P + Q = 17$. Right angles: $P^2 + Q^2 = 169$. Then $2PQ = 17^2 - 169 = 120$, $PQ = 60$; P and Q are the roots of $x^2 - 17x + 60 = 0$, so P = 12 N and Q = 5 N. At 60°: $R = \sqrt{(144 + 25 + 2 \times 12 \times 5 \times 0.5)} = \sqrt{229} \approx 15.1$ N.

- $P + Q = 17$ and $P^2 + Q^2 = 169$ (1)
- P = 12 N, Q = 5 N (1)
- R at 60° = $\sqrt{229} \approx 15.1$ N (1)

11. Three forces act on a ring that stays at rest. Two of them are $F_1 = (3\hat{i} + 4\hat{j})$ N and $F_2 = (-5\hat{i} + 2\hat{j})$ N. Find the third force F_3, its magnitude, and the angle it makes with the +x-axis. [3]

At rest, $F_1 + F_2 + F_3 = 0$, so $F_3 = -(F_1 + F_2)$. $F_1 + F_2 = (3 - 5)\hat{i} + (4 + 2)\hat{j} = -2\hat{i} + 6\hat{j}$, so $F_3 = (2\hat{i} - 6\hat{j})$ N. $|F_3| = \sqrt{(4 + 36)} = \sqrt{40} \approx 6.32$ N. $\tan\theta = -6/2 = -3$, $\theta \approx 71.6°$ below the +x-axis (in the fourth quadrant).

- $F_3 = -(F_1 + F_2) = 2\hat{i} - 6\hat{j}$ N (1)
- $|F_3| = \sqrt{40} \approx 6.3$ N (1)
- ≈ 71.6° below the +x-axis (1)

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