Motion in a Plane

Standard difficulty · 20 questions · 40 marks · Time: 36 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer — 8 × 1 = 8 marks

1. Two forces of 21 N and 24 N act at an angle of 60° to each other. The magnitude of their resultant is:
(a) 3 N **(b)** 45 N **(c)** 42 N **(d)** 39 N

2. A ball is projected at 50 m/s at 60° to the horizontal. Its horizontal range is: (Take g = 10 m/s^2.)
(a) 125√3 m **(b)** 250 m **(c)** 125 m **(d)** 500 m

3. A body is projected at 20 m/s at 30° to the horizontal. Its time of flight is: (Take g = 10 m/s^2.)
(a) 4 s **(b)** 1 s **(c)** 2√3 s **(d)** 2 s

4. A body moves in a circle of radius 1 m at a constant speed of 16 m/s. Its centripetal acceleration is:
(a) 256 m/s^2 **(b)** 16 m/s^2 **(c)** 128 m/s^2 **(d)** 257 m/s^2

5. For a given speed, a projectile has the maximum horizontal range when it is thrown at:
(a) 45° **(b)** 60° **(c)** 90° **(d)** 30°

6. A vector of magnitude 12 makes an angle of 60° with the x-axis. Its x- and y-components are:
(a) 6√3 and 6 **(b)** 6 and 6√3 **(c)** 12 and 6 **(d)** 6 and 6

7. Rain falls vertically at 12 m/s, and a person walks at 16 m/s. The speed of the rain relative to the person is:
(a) 20 m/s **(b)** 21 m/s **(c)** 28 m/s **(d)** 4 m/s

8. Assertion (A): A ball projected at 20 m/s at 60° has the same range as one projected at 20 m/s at 30°. Reason (R): sin 2θ = sin(180° − 2θ), so angles θ and 90° − θ give the same range.
(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

Section B — Short answer — 8 × 2 = 16 marks

9. Two forces of 24 N and 32 N act at right angles. Find the magnitude of their resultant and the tangent of the angle it makes with the 24 N force.

10. A ball is thrown at 30 m/s at 45° to the horizontal. Find its time of flight, greatest height and horizontal range. (Take g = 10 m/s^2.)

11. A river 150 m wide flows at 8 m/s. A boat heads straight across at 15 m/s relative to the water. Find (a) the time to cross, (b) how far downstream it lands, (c) its resultant speed.

12. A body moves round a circle of radius 49 m once every 11 s. Find its speed and centripetal acceleration. (π = 22/7)

13. A particle moves from (1, −5) m to (−8, 7) m. Find its displacement vector and the magnitude of the displacement.

14. Rain falls vertically at 36 m/s. A woman cycles east at 48 m/s. At what angle to the vertical should she hold her umbrella, and how fast does the rain hit her?

15. A ball is thrown horizontally at 18 m/s from the top of a building 80 m high. Find the time to reach the ground and the horizontal distance covered. (Take g = 10 m/s^2.)

16. If A = 0î + 5ĵ and B = 7î + 8ĵ, find A + B, A − B and |A + B|.

Section C — Word problems — 4 × 4 = 16 marks

17. Two balls are projected at 50 m/s, one at 30° and one at 60° to the horizontal. Find the range and greatest height of each. What do you notice? (Take g = 10 m/s^2.)

18. A boat can move at 17 m/s in still water. It must cross a river 285 m wide, flowing at 8 m/s, and land directly opposite. (a) At what angle to the bank, measured upstream, should it head? (b) What is its speed across the river? (c) How long does it take?

19. A cricketer can throw a ball at most 490 m on level ground. (a) With what speed does the ball leave the hand? (b) How high can the cricketer throw the same ball straight up? (c) How long is it in the air then? (Take g = 10 m/s^2.)

20. A stone tied to a string 0.9 m long is whirled in a horizontal circle, making 3 revolutions in 27 s. Find (a) its angular speed, (b) its speed, (c) its centripetal acceleration. (π = 22/7; 2 decimal places.)

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Answer key

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Q	Answer	Working
1	**(d) 39 N**	$R^2 = A^2 + B^2 + 2AB \cos\theta$
2	**(a) $125\sqrt{3}$ m**	$R = u^2 \sin 2\theta / g$
3	**(d) 2 s**	$T = 2u \sin\theta / g$
4	**(a) 256 m/s²**	$a = v^2/r$
5	**(a) 45°**	—
6	**(b) 6 and $6\sqrt{3}$**	A cos θ and A sin θ
7	**(a) 20 m/s**	$\sqrt{(12^2 + 16^2)}$
8	**(a) Both A and R are true, and R is the correct explanation of A.**	A is true: R(60°) = $20\sqrt{3}$ m; R(30°) = $20\sqrt{3}$ m. R is true and explains A.
9	**40 N; tan α = 4/3**	$R = \sqrt{(24^2 + 32^2)}$; tan α = 32/24
10	**T = $3\sqrt{2}$ s; H = 22.5 m; R = 90 m**	$T = 2u \sin\theta/g$; $H = u^2 \sin^2\theta/2g$; $R = u^2 \sin 2\theta/g$
11	**(a) 10 s; (b) 80 m; (c) 17 m/s**	time = width ÷ boat speed; drift = river speed × time
12	**28 m/s; 16 m/s²**	$v = 2\pi r/T$; $a = v^2/r$
13	**(−9î + 12ĵ) m; 15 m**	subtract the position vectors
14	**tan θ = 4/3 (towards the east); 60 m/s**	relative velocity of rain = rain − woman
15	**4 s; 72 m**	$h = \frac{1}{2}gt^2$: $80 = 5t^2$
16	**A + B = 7î + 13ĵ; A − B = −7î − 3ĵ; |A + B| = $\sqrt{218}$**	add or subtract the components
17	**30°: R = $125\sqrt{3}$ m, H = 31.25 m; 60°: R = $125\sqrt{3}$ m, H = 93.75 m. The ranges are equal, but the 60° ball goes higher.**	$R = u^2 \sin 2\theta/g$; $H = u^2 \sin^2\theta/2g$
18	**(a) cos α = 8/17 with the upstream bank (sin of the angle from the perpendicular = 8/17); (b) 15 m/s; (c) 19 s**	the upstream part of the boat's velocity must cancel the river: $\sqrt{(17^2 - 8^2)} = 15$
19	**(a) 70 m/s (maximum range u^2/g at 45°); (b) 245 m; (c) 14 s**	$R_{max} = u^2/g$; $H = u^2/2g$
20	**(a) 0.70 rad/s; (b) 0.63 m/s; (c) 0.44 m/s²**	$\omega = 2\pi n/t$; $v = \omega r$; $a = \omega^2 r$

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