



Attempt questions first; check the separate key afterward. Take $g = 10 \text{ m/s}^2$ where needed. Neglect air resistance unless stated.

A. Very short answers - 1 mark each

1. Distinguish between a scalar and a vector, with one example each.
2. What is a unit vector? Write the magnitude of a unit vector.
3. Can two unequal vectors add to zero? Justify.
4. When is the scalar product of two non-zero vectors zero?
5. When is the magnitude of a vector product maximum?
6. What is the acceleration at the highest point of a projectile?
7. Why is uniform circular motion accelerated motion?
8. For a projectile returning to its launch level, which launch angle gives maximum range?

B. Short answers / practice - 2 marks each

9. Find the magnitude and direction of $A = 3\mathbf{i} + 4\mathbf{j}$ relative to the positive x-axis.
10. If $A = 2\mathbf{i} - \mathbf{j}$ and $B = \mathbf{i} + 3\mathbf{j}$, calculate $A + B$ and $A - B$.
11. Resolve a 20 N force at 30° above the horizontal into rectangular components.
12. Calculate $A \cdot B$ and the angle between $A = \mathbf{i} + \mathbf{j}$ and $B = \mathbf{i} - \mathbf{j}$.
13. Calculate $A \times B$ for $A = 2\mathbf{i}$ and $B = 3\mathbf{j}$. State its direction.
14. A projectile is launched at 20 m/s at 30° . Find its time of flight and maximum height.
15. A ball is projected horizontally at 15 m/s from 20 m height. Find its time of flight and horizontal distance.
16. A particle travels in a circle of radius 2 m at 6 m/s. Find angular speed and centripetal acceleration.

C. Application / reasoning - 3 marks each

17. Two forces of 6 N and 8 N act at right angles. Find their resultant and its angle with the 6 N force.
18. Prove that if $|A + B| = |A - B|$ for non-zero vectors, A and B are perpendicular.
19. A projectile is fired at 25 m/s at 37° . Find range, peak height and flight time. Use $\sin 37^\circ = 0.6$ and $\cos 37^\circ = 0.8$.
20. A projectile has horizontal and vertical launch components 12 and 16 m/s. Find its velocity after 1 s and position after 2 s.

21. A river is 120 m wide. A swimmer moves at 3 m/s relative to water, perpendicular to the banks; the current is 2 m/s. Find crossing time and downstream drift.

22. A boat moves at 5 m/s relative to water in a 3 m/s river current. Find its heading and crossing time for a point directly opposite, 80 m away.

23. Rain falls vertically at 12 m/s; a cyclist moves horizontally at 5 m/s. Find the rain's velocity relative to the cyclist and umbrella angle from vertical.

24. Two projectiles have equal launch speeds at 30° and 60° . Compare their ranges, maximum heights and flight times.

25. A wheel of radius 0.5 m rotates at 120 rpm. Find rim speed and centripetal acceleration. What happens to each when rotation rate doubles?

D. Extended practice - 5 marks each

26. Derive a projectile's trajectory equation and show it is parabolic. Obtain its maximum height and horizontal range for return to the launch level.

27. Derive the magnitude and direction of the resultant of two vectors inclined at angle θ . Apply it to equal vectors and discuss $\theta = 0^\circ$ and 180° .

28. Obtain $a = v^2/r$ for uniform circular motion using the change in velocity. Express a in terms of angular speed and period.

29. Derive projectile flight time and show that complementary launch angles give equal ranges. At the angle of maximum range, prove $R = 4H$.

30. A ball is projected horizontally from a cliff. Derive its position and velocity components at time t . For height 45 m and launch speed 20 m/s, find range and impact speed.

ANSWER KEY - Numerical / closed questions

- 2) 1. 3) No; equal magnitude and opposite directions are needed. 4) At 90° . 5) At 90° . 6) g downward. 8) 45° . 9) 5; 53.13° . 10) $3\mathbf{i} + 2\mathbf{j}$; $\mathbf{i} - 4\mathbf{j}$. 11) $10\sqrt{3}$ N horizontal; 10 N vertical. 12) 0; 90° . 13) 6k, along +z. 14) 2 s; 5 m. 15) 2 s; 30 m. 16) 3 rad/s; 18 m/s^2 . 17) 10 N; 53.13° . 19) 60 m; 11.25 m; 3 s. 20) $v = 12\mathbf{i} + 6\mathbf{j} \text{ m/s}$; $r = 24\mathbf{i} + 12\mathbf{j} \text{ m}$. 21) 40 s; 80 m. 22) 36.87° upstream from the perpendicular; 20 s. 23) $-5\mathbf{i} - 12\mathbf{j} \text{ m/s}$ (east/up positive); speed 13 m/s; angle 22.62° towards cyclist motion. 24) Ranges 1:1; heights 1:3; flight times $1:\sqrt{3}$. 25) $2\pi \text{ m/s}$; $8\pi^2 \text{ m/s}^2$; speed doubles, acceleration quadruples. 30) 60 m; $10\sqrt{13} \approx 36.06 \text{ m/s}$.