4 Motion in a Plane

JEE-Main

Motion in a Plane with Constant Acceleration

1. Position of an ant (S in metres) moving in Y-Z plane is given by $S = 2t^2\,\hat{j} + 5\hat{k}$ (where t is in second). The magnitude and direction of velocity of the ant at t = 1 s will be: **[27 Jan, 2024 (Shift-I)]**

(a) 16 m/s in y-direction (b) 4 m/s in x-direction
(c) 9 m/s in z-direction (d) 4 m/s in y-direction

2. A particle starts from origin at t = 0 with a velocity $5\,\hat{i}$ m/s and moves in x-y plane under action of a force which produces a constant acceleration of $(3\,\hat{i} + 2\,\hat{j})$m/s^2. If the x-coordinate of the particle at that instant is 84 m, then the speed of the particle at this time is $\sqrt{\alpha}$ m / s. The value of α is _____. **[27 Jan, 2024 (Shift-I)]**

3. The co-ordinates of a particle moving in x-y plane are given by: $x = 2 + 4t$, $y = 3t + 8t^2$.
The motion of the particle is: **[04 April, 2024 (Shift-I)]**

(a) non-uniformly accelerated.
(b) uniformly accelerated having motion along a straight line.
(c) uniform motion along a straight line.
(d) uniformly accelerated having motion along a parabolic path.

4. A force on an object of mass 100 g is $(10\hat{i} + 5\hat{j})$N. The position of that object at t = 2s is $(a\hat{i} + b\hat{j})$m after starting from rest. The value of a/b will be _____. **[25 June, 2022 (Shift-I)]**

5. At time t = 0 a particle starts travelling from a height 7 $\hat{z}$ cm in a plane keeping z coordinate constant. At any instant of time it's position along the $\hat{x}$ and $\hat{y}$ directions are defined as $3t$ and $5t^3$ respectively. At t = 1s acceleration of the particle will be **[28 July, 2022 (Shift-II)]**

(a) $-30\,\hat{y}$ (b) $30\,\hat{y}$ (c) $3\,\hat{x} + 15\,\hat{y}$ (d) $3\,\hat{x} + 15\,\hat{y} + 7\,\hat{z}$

6. A particle is moving along the x-axis with its coordinate with time 't' given by $x(t) = 10 + 8t - 3t^2$. Another particle is moving along the y-axis with its coordinate as a function of time given by $y(t) = 5 - 8t^3$. At t = 1s, the speed of the second particle as measured in the frame of the first particle is given as $\sqrt{v}$. Then v(in m/s) is **[8 Jan, 2020 (Shift-I)]**

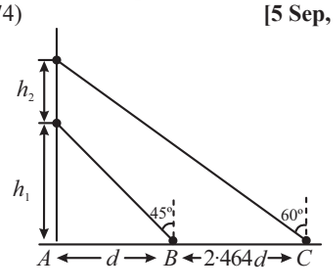
7. A particle starts from the origin at t = 0 with an initial velocity of $3.0\,\hat{i}$ m/s and moves in the x-y plane with a constant acceleration $(6.0\,\hat{i} + 4.0\,\hat{j})$ m/s^2. The x-coordinate of the particle at the instant when its y-coordinate is 32 m is D meters. The value of D is **[9 Jan, 2020 (Shift-II)]**

(a) 50 (b) 40 (c) 32 (d) 60

8. Starting from the origin at time t = 0, with initial velocity $5\,\hat{j}$ m/s, a particle moves in the x-y plane with a constant acceleration of $(10\hat{i} + 4\hat{j})$ m/s^2. At time t, its coordinates are (20 m, y_0 m). The values of t and y_0 are, respectively **[4 Sep, 2020 (Shift-I)]**

(a) 4 s and 52 m (b) 2 s and 24 m
(c) 5 s and 25 m (d) 2 s and 18 m

9. A balloon is moving up in air vertically above a point A on the ground. When it is at a height h_1, a girl standing at a distance d (point B) from A (see figure) sees it at an angle 45° with respect to the vertical. When the balloon climbs up a further height h_2, it is seen at an angle 60° with respect to the vertical if the girl moves further by a distance 2.464 d (point C). Then the height h_2 is (given tan 30° = 0.5774) **[5 Sep, 2020 (Shift-I)]**



(a) d (b) 0.732 d (c) 1.464 d (d) 0.464 d

10. A particle is moving with a velocity $\vec{v} = K(y\hat{i} + x\hat{j})$, where K is a constant. The general equation for its path is: **[9 Jan, 2019 (Shift-I)]**

(a) $y = x^2$ + constant (b) $y^2 = x$ + constant
(c) $y^2 = x^2$ + constant (d) xy = constant

11. A particle moves from the point $(2.0\hat{i} + 4.0\hat{j})$m, at t = 0 with an initial velocity $(5.0\hat{i} + 4.0\hat{j})\,\text{ms}^{-1}$. It is acted upon by a constant force which produces a constant acceleration $(4.0\hat{i} + 4.0\hat{j})\,\text{ms}^{-2}$. What is the distance of the particle from the origin at time 2s? **[11 Jan, 2019 (Shift-II)]**

(a) 15 m (b) $20\sqrt{2}$ m (c) 5 m (d) $10\sqrt{2}$ m

12. The position co-ordinates of a particle moving in a 3-D coordinates system is given by
$x = a\cos\omega t$
$y = a\sin\omega t$
and $z = a\omega t$
The speed of the particle is: **[9 Jan, 2019 (Shift-II)]**

(*a*) $\sqrt{2}\,a\omega$ (*b*) $a\omega$ (*c*) $\sqrt{3}\,a\omega$ (*d*) $2a\omega$

13. The position vector of a particle changes with time according to the relation $\vec{r}(t) = 15t^2\hat{i} + (4 - 20t^2)\hat{j}$. What is the magnitude of the acceleration at $t = 1$? **[9 April, 2019 (Shift-II)]**

(*a*) 40 m/s^2 (*b*) 100 m/s^2 (*c*) 25 m/s^2 (*d*) 50 m/s^2

"Projectile Motion: Ground to Ground Projection"

14. Projectiles *A* and *B* are thrown at angles of 45° and 60° with vertical respectively from top of a 400 m high tower. If their ranges and times of flight are same, the ratio of their speeds of projection v_A : v_B is: **[30 Jan, 2024 (Shift-II)]**

(*a*) $1:\sqrt{3}$ (*b*) $\sqrt{2}:1$ (*c*) $1:2$ (*d*) $1:\sqrt{2}$

15. A particle moving in a circle of radius *R* with uniform speed takes time *T* to complete one revolution. If this particle is projected with the same speed at an angle θ to the horizontal, the maximum height attained by it is equal to 4*R*. The angle of projection θ is then given by: **[1 Feb, 2024 (Shift-I)]**

(*a*) $\sin^{-1}\left[\frac{2gT^2}{\pi^2 R}\right]^{\frac{1}{2}}$ (*b*) $\sin^{-1}\left[\frac{\pi^2 R}{2gT^2}\right]^{\frac{1}{2}}$

(*c*) $\cos^{-1}\left[\frac{2gT^2}{\pi^2 R}\right]^{\frac{1}{2}}$ (*d*) $\cos^{-1}\left[\frac{\pi R}{2gT^2}\right]^{\frac{1}{2}}$

16. The maximum height reached by a projectile is 64 m. If the initial velocity is halved, the new maximum height of the projectile is _____ m. **[05 April, 2024 (Shift-II)]**

17. The angle of projection for a projectile to have same horizontal range and maximum height is: **[08 April, 2024 (Shift-II)]**

(*a*) $\tan^{-1}(2)$ (*b*) $\tan^{-1}(4)$ (*c*) $\tan^{-1}\left(\frac{1}{4}\right)$ (*d*) $\tan^{-1}\left(\frac{1}{2}\right)$

18. The range of the projectile projected at an angle of 15° with horizontal is 50 m. If the projectile is projected with same velocity at an angle of 45° with horizontal, then its range will be: **[10 April, 2023 (Shift-I)]**

(*a*) 50 *m* (*b*) $50\sqrt{2}\,m$ (*c*) 100 *m* (*d*) $100\sqrt{2}\,m$

19. The initial speed of a projectile fired from ground is *u*. At the highest point during its motion, the speed of projectile is $\frac{\sqrt{3}}{2}u$. The time of flight of the projectile is: **[31 Jan, 2023 (Shift-I)]**

(*a*) $\frac{u}{2g}$ (*b*) $\frac{u}{g}$ (*c*) $\frac{2u}{g}$ (*d*) $\frac{\sqrt{3}u}{g}$

20. The trajectory of projectile, projected from the ground is given by $y = x - \frac{x^2}{20}$. Where *x* and *y* are measured in meter. The maximum height attained by the projectile will be. **[8 April, 2023 (Shift-II)]**

(*a*) 5 *m* (*b*) $10\sqrt{2}\,m$ (*c*) 200 *m* (*d*) 10 *m*

21. For a body projected at an angle with the horizontal from the ground, choose the correct statement. **[1 Feb, 2023 (Shift-II)]**

(*a*) Gravitational potential energy is maximum at the highest point.
(*b*) The horizontal component of velocity is zero at highest point.
(*c*) The vertical component of momentum is maximum at the highest point.
(*d*) The kinetic energy (K.E.) is zero at the highest point of projectile motion.

22. Given below are two statements : one is labelled as **Assertion A** and the other is labelled as **Reason R.**
Assertion A: When a body is projected at an angle 45°, it's range is maximum.
Reason R: For maximum range, the value of sin2θ should be equal to one.
In the light of the above statements, choose the correct answer from the options given below: **[6 April, 2023 (Shift-I)]**

(*a*) Both A and R are correct but R is NOT the correct explanation of A
(*b*) Both A and R are correct R is the correct explanation of A
(*c*) A is true but R is false
(*d*) A is false but R is true

23. A projectile is projected at 30° from horizontal with initial velocity 40 ms^{-1}. The velocity of the projectile at $t = 2$ s from the start will be: (Given $g = 10\ m/s^2$) **[11 April, 2023 (Shift-II)]**

(*a*) $20\sqrt{3}\,ms^{-1}$ (*b*) $40\sqrt{3}\,ms^{-1}$
(*c*) 20 ms^{-1} (*d*) Zero

24. Two objects are projected with the same velocity '*u*' however at different angles α and β with the horizontal. If $\alpha + \beta = 90°$, the ratio of horizontal range of the first object to the 2nd object will be: **[25 Jan, 2023 (Shift-II)]**

(*a*) 4 : 1 (*b*) 2 : 1 (*c*) 1 : 2 (*d*) 1 : 1

25. Two projectiles are projected at 30° and 60° with the horizontal with the same speed. The ratio of the maximum height attained by the two projectiles respectively is: **[10 April, 2023 (Shift-II)]**

(*a*) $2:\sqrt{3}$ (*b*) $\sqrt{3}:1$ (*c*) 1 : 3 (*d*) $1:\sqrt{3}$

26. The maximum vertical height to which a man can throw a ball is 136 *m*. The maximum horizontal distance upto which he can throw the same ball is **[24 Jan, 2023 (Shift-I)]**

(*a*) 192 *m* (*b*) 136 *m* (*c*) 272 *m* (*d*) 68 *m*

27. A projectile fired at 30° to the ground is observed to be at same height at time 3*s* and 5s after projection, during its flight. The speed of projection of the projectile is _____ ms^{-1}
(Given g = 10 ms^{-2}) **[11 April, 2023 (Shift-I)]**

28. Two bodies are projected from ground with same speeds 40ms^{-1} at two different angles with respect to horizontal. The bodies were found to have same range. If one of the body was projected at an angle of 60°, with horizontal then sum of the maximum heights, attained by the two projectiles, is_____ m. (Given g = 10ms^{-2})
[31 Jan, 2023 (Shift-II)]

29. A stone is projected at angle 30° to the horizontal. The ratio of kinetic energy of the stone at point of projection to its kinetic energy at the highest point of flight will be **[29 Jan, 2023 (Shift-I)]**

(*a*) 1 : 2 (*b*) 1 : 4 (*c*) 4 : 1 (*d*) 4 : 3

30. Two projectiles *A* and *B* are thrown with initial velocities of 40 m/s and 60 m/s at angles 30° and 60° with the horizontal respectively. The ratio of their ranges respectively is ($g = 10\ m/s^2$) **[8 April, 2023 (Shift-I)]**

(*a*) $\sqrt{3}:2$ (*b*) $2:\sqrt{3}$ (*c*) 1 : 1 (*d*) 4 : 9

31. Given below are two statements. One is labelled as **Assertion A** and the other is labelled as **Reason R**.

Assertion A: Two identical balls *A* and *B* thrown with same velocity 'u' at two different angles with horizontal attained the same range *R*. If *A* and *B* reached the maximum height h_1 and h_2 respectively, then $R = 4\sqrt{h_1 h_2}$

Reason R: Product of said heights.

$$h_1 h_2 = \left(\frac{u^2 \sin^2\theta}{2g}\right)\cdot\left(\frac{u^2\cos^2\theta}{2g}\right)$$

Choose the correct answer: **[25 June, 2022 (Shift-II)]**

(*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.

32. A projectile is launched at an angle 'α' with the horizontal with a velocity 20 ms^{-1}. After 10 s, it inclination with horizontal is 'β'. The value of tan β will be: ($g = 10\ ms^{-2}$). **[27 June, 2022 (Shift-I)]**

(*a*) tanα + 5secα (*b*) tanα – 5secα
(*c*) 2 tanα – 5secα (*d*) 2tanα + 5secα

33. Two projectiles are thrown with same initial velocity making an angle of 45° and 30° with the horizontal respectively. The ratio of their respective ranges will be: **[26 July, 2022 (Shift-II)]**

(*a*) $1:\sqrt{2}$ (*b*) $\sqrt{2}:1$ (*c*) $2:\sqrt{3}$ (*d*) $\sqrt{3}:2$

34. A body of mass 10 kg is projected at an angle of 45° with the horizontal. The trajectory of the body is observed to pass through a point (20, 10). If *T* is the time of flight, then its momentum vector, at time $t = \frac{T}{\sqrt{2}}$ is_____

[Take $g = 10\ m/s^2$] **[27 July, 2022 (Shift-II)]**

(*a*) $100\hat{i} + \left(100\sqrt{2} - 200\right)\hat{j}$ (*b*) $100\sqrt{2}\,\hat{i} + \left(100 - 200\sqrt{2}\right)\hat{j}$

(*c*) $100\hat{i} + \left(100 - 200\sqrt{2}\right)\hat{j}$ (*d*) $100\sqrt{2}\,\hat{i} + \left(100\sqrt{2} - 200\right)\hat{j}$

35. A projectile is projected with velocity of 25 m/s at an angle θ with the horizontal. After *t* seconds its inclination with horizontal becomes zero. If *R* represents horizontal range of the projectile, the value of θ will be: **[24 June, 2022 (Shift-I)]**

(*a*) $\frac{1}{2}\sin^{-1}\left(\frac{5t^2}{4R}\right)$ (*b*) $\frac{1}{2}\sin^{-1}\left(\frac{4R}{5t^2}\right)$

(*c*) $\tan^{-1}\left(\frac{4t^2}{5R}\right)$ (*d*) $\cot^{-1}\left(\frac{R}{20t^2}\right)$

36. A ball is projected from the ground with a speed 15 ms^{-1} at an angle θ with horizontal so that its range and maximum height are equal. Then 'tanθ' will be equal to: **[25 July, 2022 (Shift-II)]**

(*a*) 1/4 (*b*) 1/2 (*c*) 2 (*d*) 4

37. A person can throw a ball upto a maximum range of 100 m. How high above the ground he can throw the same ball? **[29 June, 2022 (Shift-II)]**

(*a*) 25 m (*b*) 50 m (*c*) 100 m (*d*) 200 m

38. A body is projected from the ground at an angle of 45° with horizontal. Its velocity after 2s is 20 ms^{-1}. The maximum height reached by the body during its motion is _____m. (use $g = 10 ms^{-2}$) **[24 June, 2022 (Shift-II)]**

39. If the initial velocity in horizontal direction of a projectile is unit vector $\hat{i}$ and the equation of trajectory is $y = 5x(1 - x)$. The *y* component vector of the initial velocity is _____$\hat{j}$. (Take $g = 10\ m/s^2$) **[26 July, 2022 (Shift-I)]**

40. An object is projected in the air with initial velocity *u* at an angle θ. The projectile motion is such that the horizontal range *R*, is maximum. Another object is projected in the air with a horizontal range half of the range of first object. The initial velocity remains same in both the case. The value of the angle of projection, at which the second object is projected, will be _____ degree. **[29 July, 2022 (Shift-I)]**

41. A ball is projected with kinetic energy *E*, at an angle of 60° to the horizontal. The kinetic energy of this ball at the highest point of its flight will become: **[29 July, 2022 (Shift-I)]**

(*a*) Zero (*b*) $\frac{E}{2}$ (*c*) $\frac{E}{4}$ (*d*) *E*

42. Two projectile thrown at 30° and 45° with the horizontal respectively, reach the maximum height in same time. The ratio of their initial velocities is **[26 July, 2022 (Shift-I)]**

(*a*) $1:\sqrt{2}$ (*b*) 2 : 1 (*c*) $\sqrt{2}:1$ (*d*) 1 : 2

43. A ball of mass m is thrown vertically upward. Another ball of mass 2 m is thrown an angle θ with the vertical. Both the balls stay in air for the same period of time. The ratio of the heights attained by the two balls respectively is $\frac{1}{x}$. The value of *x* is _____. **[27 July, 2022 (Shift-I)]**

44. A body is projected at $t = 0$ with a velocity 10 ms^{-1} at an angle of 60° with the horizontal. The radius of curvature of its trajectory at $t = 1\ s$ is *R*. Neglecting air resistance and taking acceleration due to gravity $g = 10\ ms^{-2}$ the radius of *R* is: **[11 Jan, 2019 (Shift-I)]**

(*a*) 10.3 m (*b*) 2.8 m (*c*) 2.5 m (*d*) 5.1 m

45. Two guns *A* and *B* can fire bullets at speed 1 km/s and 2 km/s respectively. From a point on a horizontal ground, they are fired in all possible directions. The ratio of maximum areas covered by the bullets fired by the two guns, on the ground is: **[10 Jan, 2019 (Shift-I)]**

(*a*) 1 : 16 (*b*) 1 : 2 (*c*) 1 : 4 (*d*) 1 : 8

46. A shell is fired from a fixed artillery gun with an initial speed *u* such that it hits the target on the ground at a distance *R* from it. If t_1 and t_2 are the values of the time taken by it to hit the target in two possible ways, the product $t_1 t_2$ is: **[12 April, 2019 (Shift-I)]**

(*a*) *R*/*g* (*b*) *R*/4*g* (*c*) 2*R*/*g* (*d*) *R*/2*g*

47. Two particles are projected from the same point with the same speed u such that they have the same range *R*, but different maximum heights, h_1 and h_2. Which of the following is correct? **[12 April, 2019 (Shift-II)]**

(*a*) $R^2 = 2h_1 h_2$ (*b*) $R^2 = 16h_1 h_2$ (*c*) $R^2 = 4h_1 h_2$ (*d*) $R^2 = h_1 h_2$

48. The trajectory of a projectile near the surface of the earth is given as $y = 2x - 9x^2$. If it were launched at an angle θ_0 with speed v_0 then (g =10 ms^{-2}) **[12 April, 2019 (Shift-I)]**

(*a*) $\theta_0 = \cos^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5}$ ms^{-1}

(*b*) $\theta_0 = \sin^{-1}\left(\frac{1}{\sqrt{5}}\right)$ and $v_0 = \frac{5}{3}$ms^{-1}

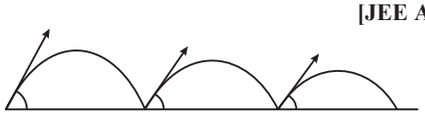
(*c*) $\theta_0 = \sin^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5}$ms^{-1}

(*d*) $\theta_0 = \cos^{-1}\left(\frac{1}{\sqrt{5}}\right)$ and $v_0 = \frac{5}{3}$ms^{-1}

49. A ball is thrown from ground at an angle θ with horizontal and with an initial speed u_0. For the resulting projectile motion, the magnitude of average velocity of the ball up to the point when it hits the ground for the first time is V_1

After hitting the ground, ball rebounds at the same angle θ but with a reduced speed of u_0/α. Its motion continues for a long time as shown in figure. If the magnitude of average velocity of the ball for entire duration of motion is 0.8 V_1, the value of α is_____

[JEE Adv, 2019]



Horizontal Projectile

50. A ball rolls off the top of a stairway with horizontal velocity u. The steps are 0.1 m high and 0.1 m wide. The minimum velocity u with which that ball just hits the step 5 of the stairway will be $\sqrt{x}$ ms^{-1} where x = _____ [use g = 10 m/s^2].**[29 Jan, 2024 (Shift-I)]**

51. A body of mass M thrown horizontally with velocity v from the top of the tower of height H touches the ground at a distance of 100m from the foot of the tower. A body of mass 2 M thrown at a velocity $v/2$ from the top of the tower of height $4H$ will touch the ground at a distance of ……. m. **[08 April, 2024 (Shift-II)]**

52. A child stands on the edge of the cliff 10 m above the ground and throws a stone horizontally with an initial speed of 5 ms^{-1}. Neglecting the air resistance, the speed with which the stone hits the ground will be ms^{-1} (given, g = 10 ms^{-1}).

[1 Feb, 2023 (Shift-I)]

(*a*) 20 (*b*) 15 (*c*) 30 (*d*) 25

53. A helicopter rises from rest on the ground vertically upwards with a constant acceleration g. A food packet is dropped from the helicopter when it is at a height h. The time taken by the packet to reach the ground is close to [g is the acceleration due to gravity]

[5 Sep, 2020 (Shift-I)]

(*a*) $t = 3.4\sqrt{\left(\frac{h}{g}\right)}$ (*b*) $t = 1.8\sqrt{\frac{h}{g}}$

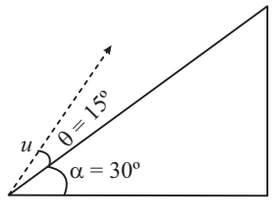
(*c*) $t = \sqrt{\frac{2h}{3g}}$ (*d*) $t = \frac{2}{3}\sqrt{\left(\frac{h}{g}\right)}$

Projectile Motion on an Inclined Plane

54. A plane is inclined at an angle α = 30° with a respect to the horizontal. A particle is projected with a speed u = 2 ms^{-1} from the base of the plane, making an angle θ = 15° with respect to the plane as shown in the figure.

The distance from the base, at which the particle hits the plane is close to: **[10 April, 2019 (Shift-II)]**

(Take g = 10 ms^{-2})



(*a*) 14 cm (*b*) 20 cm (*c*) 18 cm (*d*) 26 cm

Two Dimensional Relative Motion

55. The speed of a swimmer is 4 km h^{-1} in still water. If the swimmer makes his strokes normal to the flow of river of width 1 km, he reaches a point 750 m down the stream on the opposite bank.

The speed of the river water is _____ km h^{-1}.

[31 Jan, 2023 (Shift-I)]

56. A fighter jet is flying horizontally at a certain with a speed of 200 ms^{-1}.When it passes directly overhead an anti-aircraft gun, a bullet is fired from the gun, at an angle θ with the horizontal, to hit the jet. If the bullet speed is 400 m/s, the value of θ will be _____.

[26 June, 2022 (Shift-I)]

57. A girl standing on road holds her umbrella at 45° with the vertical to keep the rain away. If she starts running without umbrella with a speed of $15\sqrt{2}$ kmh^{-2}, the rain drops hit her head vertically. The speed of rain drops with respect to the moving girl is:

[27 June, 2022 (Shift-I)]

(*a*) 30 kmh–1 (*b*) $\frac{25}{\sqrt{2}}$kmh^{-1}

(*c*) $\frac{30}{\sqrt{2}}$kmh^{-1} (*d*) 25 kmh–1

58. When a car is at rest, its driver sees rain drops falling on it vertically. When driving the car with speed v, he sees that rain drops are coming at an angle 60º from the horizontal. On further increasing the speed of the car to (1 + β)v, this angle changes to 45º. The value of β is close to **[6 Sep, 2022 (Shift-II)]**

(*a*) 0.37 (*b*) 0.41 (*c*) 0.73 (*d*) 0.50

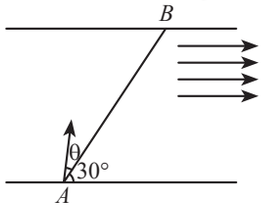
59. A butterfly is flying with a velocity $4\sqrt{2}$ m/s in North – East direction. Wind is slowly blowing at 1 m/s from North to South. The resultant displacement of the butterfly in 3 seconds is:

[20 July, 2021 (Shift-I)]

(*a*) 15m (*b*) 20m (*c*) 3 m (*d*) $12\sqrt{2}m$

60. A swimmer wants to cross a river from point A to point B. Line AB makes an angle of 30° with the flow of river. Magnitude of velocity of the swimmer is same as that of the river. The angle θ with the line AB should be _____ °, so that the swimmer reaches point B.

[27 July, 2021 (Shift-II)]



61. A swimmer can swim with velocity of 12 km/ h in still water. Water flowing in a river has velocity 6 km/ h. The direction with respect to the direction of flow of river water he should swim in order to reach the point on the other bank just opposite to his starting point is _____°. (Round off to the Nearest Integer)
(Find the angle in degrees) **[16 March, 2021 (Shift-II)]**

62. A person is swimming with a speed of 10 m/s at an angle of 120° with the flow and reaches to a point directly opposite on the other side of the river. The speed of the flow is 'x' m/s. The value of 'x' to the nearest integer is _____. **[18 March, 2021 (Shift-I)]**

63. Ship A is sailing towards north-east with velocity $\vec{v} = 30\hat{i} + 50\hat{j}$ km/hr where $\hat{i}$ points east and $\hat{j}$, north. Ship B is at a distance of 80 km east and 150 km north of Ship A and is sailing towards west at 10 km/hr. A will be at minimum distance from B in:

[8 April, 2019 (Shift-I)]

(*a*) 4.2 hrs. (*b*) 2.2 hrs. (*c*) 3.2 hrs. (*d*) 2.6 hrs.

64. The stream of a river is flowing with a speed of 2km/h. A swimmer can swim at a speed of 4km/h. What should be the direction of the swimmer with respect to the flow of the river to cross the river straight? **[9 April, 2019 (Shift-I)]**

(*a*) 60° (*b*) 150° (*c*) 90° (*d*) 120°

Uniform Circular Motion

65. If the radius of curvature of the path of two particles of same mass are in the ratio 3:4, then in order to have constant centripetal force, their velocities will be in the ratio of: **[29 Jan, 2024 (Shift-I)]**

(*a*) $\sqrt{3}$: 2 (*b*) 1: $\sqrt{3}$ (*c*) $\sqrt{3}$: 1 (*d*) 2 : $\sqrt{3}$

66. A particle is moving in a circle of radius 50 cm in such a way that at any instant the normal and tangential components of its acceleration are equal. If its speed at $t = 0$ is 4 m/s, the time taken to complete the first revolution will be $\frac{1}{\alpha}[1 - e^{-2\pi}]s$, where α = _____. is

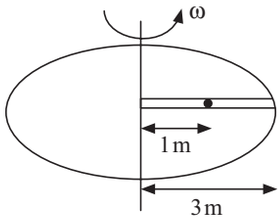
[29 Jan, 2024 (Shift-II)]

67. A clock has 75 cm, 60 cm long second hand and minute hand respectively. In 30 minutes duration the tip of second hand will travel x distance more than the tip of minute hand. The value of x in meter is nearly (Take π = 3.14): **[08 April, 2024 (Shift-I)]**

(*a*) 139.4 (*b*) 140.5 (*c*) 220.0 (*d*) 118.9

68. A circular table is rotating with an angular velocity of ω rad/s about its axis (see figure). There is a smooth groove along a radial direction on the table. A steel ball is gently placed at a distance of 1 m on the groove. All the surface are smooth. If the radius of the table is 3 m, the radial velocity of the ball w.r.t. the table at the time ball leaves the table is $x\sqrt{2}\omega$ m/s, where the value of x is……..

[08 April, 2024 (Shift-II)]



69. An object moves at a constant speed along a circular path in a horizontal plane with centre at the origin. When the object is at $x = +2m$, its velocity is $-4\hat{j}m/s$. The object's velocity (v) and acceleration (a) at $x = -2m$ will be **[29 Jan, 2023 (Shift-II)]**

(*a*) $v = 4\hat{i}m/s, a = 8\hat{j}m/s^2$ (*b*) $v = 4\hat{j}m/s, a = 8\hat{i}m/s^2$

(*c*) $v = -4\hat{j}m/s, a = 8\hat{i}m/s^2$ (*d*) $v = -4\hat{i}m/s, a = -8\hat{j}m/s^2$

70. A car is moving on a circular path of radius 600 m such that the magnitudes of the tangential and centripetal acceleration are equal. Time taken by the car to complete first quarter of revolution, if it is moving with an initial speed of 54 km/hr is $t(1 - e^{-\pi/2})s$. The value of t is _____. **[29 Jan, 2023 (Shift-II)]**

71. A stone tied to 180 cm long string at its end is making 28 revolutions in horizontal circle in every minute.The magnitude of acceleration of stone is $\frac{1936}{x}ms^{-2}$. The value of x _____.

$\left(\text{Take } \pi = \frac{22}{7}\right)$ **[30 Jan, 2023 (Shift-II)]**

72. A ball is spun with angular acceleration $\alpha = 6t^2 - 2t$ where t is in second and α is in $rads^{-1}$. At $t = 0$, the ball has angular velocity of 10 $rads^{-1}$ and angular position of 4 rad. The most appropriate expression for the angular position of the ball is: **[28 June, 2022 (Shift-II)]**

(*a*) $\frac{3}{2}t^4 - t^2 + 10t$ (*b*) $\frac{t^4}{2} - \frac{t^3}{3} + 10t + 4$

(*c*) $\frac{2t^4}{3} - \frac{t^3}{6} + 10t + 12$ (*d*) $2t^4 - \frac{t^3}{2} + 5t + 4$

73. Motion of a particle in $x - y$ plane is described by a set of following equations $x = 4\sin\left(\frac{\pi}{2} - \omega t\right)$ m and $y = 4\sin(\omega t)$m. The path of the particle will be: **[28 June, 2022 (Shift-I)]**

(*a*) Circular (*b*) Helical

(*c*) Parabolic (*d*) Elliptical

74. A fly wheel is accelerated uniformly from rest and rotates through 5 rad in the first second. The angle rotated by the fly wheel in the next second, will be: **[24 June, 2022 (Shift-II)]**

(*a*) 7.5 rad (*b*) 15 rad (*c*) 20 rad (*d*) 30 rad

75. A body rotating with an angular speed of 600rpm is uniformly accelerated to 1800rpm in 10 sec. The number of rotations made in the process is _____. **[20 July, 2021 (Shift-II)]**

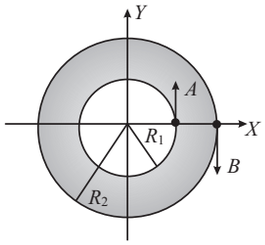
76. A particle moves such that its position vector $\vec{r}(t) = \cos\omega\,\hat{i} + \sin\omega t\,\hat{j}$ where ω is a constant and t is time. Then which of the following statements is true for the velocity $\vec{v}(t)$ and acceleration $\vec{a}(t)$ of the particle: **[8 Jan, 2020 (Shift-II)]**

(*a*) $\vec{v}$ is perpendicular to $\vec{r}$ and $\vec{a}$ is directed towards the origin.
(*b*) $\vec{v}$ and $\vec{a}$ both are parallel to $\vec{r}$.
(*c*) $\vec{v}$ is perpendicular to $\vec{r}$ and $\vec{a}$ is directed away from the origin.
(*d*) $\vec{v}$ and $\vec{a}$ both are perpendicular to $\vec{r}$.

77. A particle is moving along a circular path with a constant speed of 10 ms^{-1}. What is the magnitude of the change in velocity of the particle, when it moves through an angle of 60° around the centre of the circle? **[11 Jan, 2019 (Shift-I)]**

(*a*) $10\sqrt{3}$ m/s (*b*) 0
(*c*) $10\sqrt{2}$ m/s (*d*) 10 m/s

78. Two particles *A*, *B* are moving on two concentric circles of radii R_1 and R_2 with equal angular speed ω. At $t = 0$, their positions and direction of motion are shown in the figure: **[12 Jan, 2019 (Shift-II)]**



The relative velocity $\overrightarrow{v_A} - \overrightarrow{v_B}$ at $t = \dfrac{\pi}{2\omega}$ is given by:

(*a*) $\omega(R_1 + R_2)\hat{i}$ (*b*) $-\omega(R_1 + R_2)\hat{i}$
(*c*) $\omega(R_2 - R_1)\hat{i}$ (*d*) $\omega(R_1 - R_2)\hat{i}$

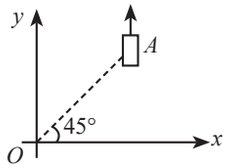
JEE-Advanced

Position, Distance and Displacement

Subjective

1. On a frictionless horizontal surface, assumed to be the $x-y$ plane, a small trolley *A* is moving along a straight line parallel to the *y*-axis (see figure) with a constant velocity of $(\sqrt{3}-1)$m/s . At a particular instant when the line *OA* makes an angle of 45° with the *x*-axis, a ball is thrown along the surface from the origin *O*. Its velocity makes an angle ϕ with the *x*-axis and it hits the trolley.

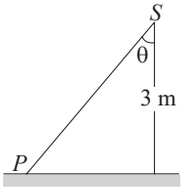
(*a*) The motion of the ball is observed from the frame of the trolley. Calculate the angle θ made by the velocity vector of the ball with the *x*-axis in this frame.



(*b*) Find the speed of the ball with respect to the surface, if $\phi = 4\theta/3$. **(IIT-JEE 2002)**

Fill in the Blanks

2. Spotlight *S* rotates in a horizontal plane with constant angular velocity of 0.1 rad/s. The spot of light *P* moves along the wall at a distance of 3m. The velocity of the spot *P* when $\theta = 45°$ (see fig.) is……. m/s. **(IIT-JEE 1987)**



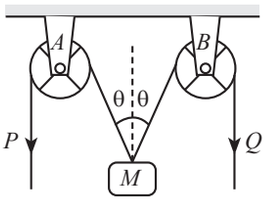
3. Four persons *K*, *L*, *M*, *N* are initially at the four corners of a square of side *d*. Each person now moves with a uniform speed *v* in such a way that *K* always moves directly towards *L*, *L* directly towards *M*, *M* directly towards *N* and *N* directly towards *K*. The four persons will meet at a time …… **(IIT-JEE 1984)**

4. A particle moves in a circle of radius *R*. In half the period of revolution , its displacement is … and distance covered is ….
(IIT-JEE 1983)

Speed and Velocity

Single Correct

5. In the arrangement shown in the figure, the ends *P* and *Q* of an unstretchable string move downwards with uniform speed *U*. Pulleys *A* and *B* are fixed. Mass *M* moves upwards with a speed



(IIT-JEE 1982)

(*a*) $2U\cos\theta$ (*b*) $\dfrac{U}{\cos\theta}$ (*c*) $2U\cos\theta$ (*d*) $U\cos\theta$

Multiple Correct

6. The coordinates of a particle moving in a plane are given by $x(t) = a\cos(pt)$ and $y(t) = b\sin(pt)$ where a, $b(< a)$ and p are positive constants of appropriate dimensions. Then, **(IIT-JEE 1999)**

(*a*) The path of the particle is an ellipse
(*b*) The velocity and acceleration of the particle are normal to each other at $t = \pi/2p$
(*c*) The acceleration of the particle is always directed towards a focus
(*d*) The distance traveled by the particle in time interval $t = 0$ to $t = \pi/2p$ is a

Constant Acceleration

Single Correct

7. A particle is moving Eastwards with a velocity of 5 m/s. In 10 s, the velocity changes to 5 m/s Northwards. The average acceleration in this time is **(IIT-JEE 1982)**

(*a*) Zero

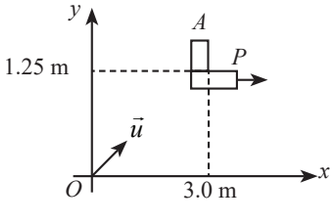
(*b*) $\frac{1}{\sqrt{2}}$ m/s^2 towards North-East

(*c*) $\frac{1}{\sqrt{2}}$ m/s^2 towards North-West

(*d*) $\frac{1}{2}$ m/s^2 towards North

Subjective

8. An object A is kept fixed at the point $x = 3$ m and $y = 1.25$ m on a plank P raised above the ground. At time $t = 0$, the plank starts moving along the $+x$-direction with an acceleration 1.5 m/s^2. At the same instant, a stone is projected from the origin with a velocity u as shown. A stationary person on the ground observes the stone hitting the object during its downward motion at an angle of 45° to the horizontal. All the motions are in $x - y$ plane. Find u and the time after which the stone hits the object. (Take $g = 10$ m/s^2).

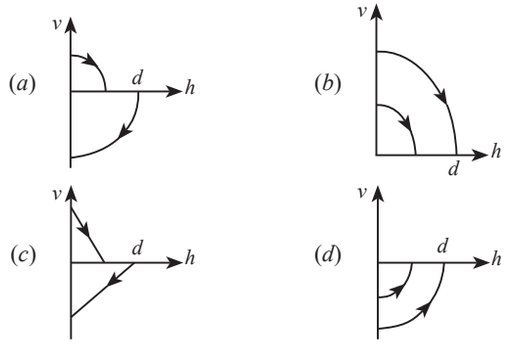


(IIT-JEE 2000)

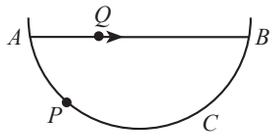
Motion Under Gravity

Single Correct

9. A ball is dropped vertically from a height d above the ground. It hits the ground and bounces up vertically to a height $d/2$. Neglecting subsequent motion and air resistance, its velocity v varies with height h above the ground as **(IIT-JEE 2000)**



10. A particle P is sliding down a frictionless hemispherical bowl. It passes the point A at $t = 0$. At this instant of time, the horizontal component of its velocity is v. A bead Q of the same mass as P is ejected from A at $t = 0$ along the horizontal string AB, with the speed v. Friction between the bead and the string may be neglected. Let t_P and t_Q be the respective times taken by P and Q to reach the point B.



Then **(IIT-JEE 1993)**

(*a*) $t_P < t_Q$ (*b*) $t_P = t_Q$

(*c*) $t_P > t_Q$ (*d*) $\frac{t_P}{t_Q} = \frac{\text{length of } arc\ ACB}{\text{length of chord } AB}$

Numerical Types

11. A body falling freely from a given height H hits an inclined plane in its path at a height h. As a result of this impact the direction of the velocity of the body becomes horizontal. For what value of (h/H), the body will take maximum time to reach the ground? **(IIT-JEE 1986)**

True/False

12. Two balls of different masses are thrown vertically upwards with the same speed. They pass through the point of projection in their downward motion with the same speed (Neglect air resistance).

(IIT-JEE 1983)

Projectile Motion: Ground To Ground Projection

Single Correct

13. A train is moving along a straight line with a constant acceleration a. A boy standing in the train throws a ball forward with a speed of 10 m/s, at an angle of 60° to the horizontal. The boy has to move forward by 1.15 m inside the train to catch the ball back at the initial height. The acceleration of the train, in m/s^2, is. **(IIT-JEE 2011)**

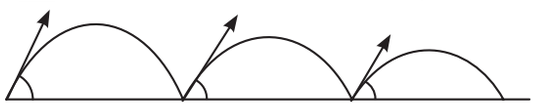
(*a*) 2 m/s^2 (*b*) 4 m/s^2 (*c*) 3 m/s^2 (*d*) 5 m/s^2

Numerical Types

14. A projectile is fired from horizontal ground with speed v and projection angle θ. When the acceleration due to gravity is g, the range of the projectile is d. If at the highest point in its trajectory, the projectile enters a different region where the effective acceleration due to gravity is $g' = \frac{g}{0.81}$ then the new range is $d' = nd$. The value of n is_____.

C 12.85 W 67.44 UA 19.71 (JEE Adv. 2022)

15. A ball is thrown from ground at an angle θ with horizontal and with an initial speed u_0. For the resulting projectile motion, the magnitude of average velocity of the ball up to the point when it hits the ground for the first time is V_1. After hitting the ground, ball rebounds at the same angle θ but with a reduced speed of u_0/α. Its motion continues for a long time as shown in figure. If the magnitude of average velocity of the ball for entire duration of motion is $0.8\ V_1$, the value of α is___ **C-17.79 W-62.13 UA-20.07 (JEE Adv. 2019)**



Fill in the Blanks

16. The trajectory of a projectile in a vertical plane is $y = ax - bx^2$, where a, b are constants, and x and y are respectively, the horizontal and vertical distances of the projectile from the point of projection. The maximum height attained is….. and the angle of projection from the horizontal is…. **(IIT-JEE 1997)**

True/False

17. A projectile fired from the ground follows a parabolic path. The speed of the projectile is minimum at the top of its path **(IIT-JEE 1984)**

Comprehension Based/Statement Based

Question Stem for Question Nos. 22 and 23:

A projectile is thrown from a point O on the ground at an angle 45° from the vertical and with a speed $5\sqrt{2}$ m/s. The projectile at the highest point of its trajectory splits into two equal parts. One part falls vertically down to the ground 0.5 s after the splitting. The other part, t seconds after the splitting, falls to the ground at a distance x meters from the point O. The acceleration due to gravity $g = 10$ m/s^2. **(JEE Adv. 2021)**

18. The value of t is _____. **C-37 43W-50 49 UA-12 09**

19. The value of x is _____. **C-18 78 W-68 69 UA-12 53**

Projectile Thrown From Some Height Above Ground

Subjective

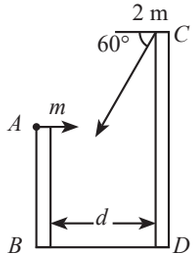
20. Two guns situated on the top of a hill of height 10 m fire one shot each with the same speed $5\sqrt{3}$ m/s at some interval of time. One gun fires horizontally and other fires upwards at an angle of 60° with the horizontal. The shots collide in air at point $P(g = 10$ m/s$^2)$.

(*a*) Find the time interval between the firings and

(*b*) The coordinates of the point P. Take origin of the coordinate system at the foot of the hill right below the muzzle and trajectories in $x - y$ plane. **(IIT-JEE 1996)**

21. Two towers AB and CD are situated a distance d apart as shown in figure. AB is 20 m high and CD is 30 m high from the ground. An object of mass m is thrown from the top of AB horizontally with a velocity of 10 m/s towards CD.

Simultaneously, another object of mass 2 m is thrown from the top of CD at an angle of 60° to the horizontal towards AB with the same magnitude of initial velocity as that of the first object. The two objects move in the same vertical plane, collide in mid-air and stick to each other. **(IIT-JEE 1994)**



(*a*) Calculate the distance d between the towers.

(*b*) Find the position where the objects hit the ground.

One Dimensional Relative Motion

Single Correct

22. **Statement-I:** For an observer looking out through the window of a fast moving train, the nearby objects appear to move in the opposite direction to the train, while the distant objects appear to be stationary.

Statement-II : If the observer and the object are moving at velocities v_1 and v_2, respectively with reference to a laboratory frame, the velocity of the object with respect to the observer is $v_2 - v_1$

(IIT-JEE 2008)

(*a*) Statement-I is true, Statement-II is true; Statement-II is the correct explanation for Statement-I

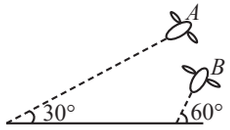
(*b*) Statement-I is the, Statement-II is true; Statement-II is not a correct explanation for Statement-I

(*c*) Statement-I is true; Statement-II is false

(*d*) Statement-I is false; Statement-II is the

Numerical Types

23. Airplanes A and B are flying with constant velocity in the same vertical plane at angles 30° and 60° with respect to the horizontal respectively as shown in the figure. The speed of A is $100\sqrt{3}$ ms^{-1}. At the time $t = 0$s, an observer in A finds B at a distance of 500 m. This observer sees B moving with a constant velocity perpendicular to the line of motion of A. If at $t = t_0$, A just escapes being hit by B, t_0 in seconds is **C-28.28 W-59.26 UA-12.46 (JEE Adv. 2014)**



Subjective

24. A cart is moving along x-direction with a velocity of 4 m/s. A person on the cart throws a stone with a velocity of 6 m/s relative to himself. In the frame of reference of the cart, the stone is thrown in $y - z$ plane making an angle of 30° with vertical z-axis. At the highest point of its trajectory, the stone hits an object of equal mass hung vertically from branch of a tree by means of a string of length L.

A completely inelastic collision occurs, in which the stone gets embedded in the object. Determine ($g = 9.8$ m/s^2)

(*a*) the speed of the combined mass immediately after the collision with respect to an observer on the ground.

(*b*) the length L of the string such that tension in the string becomes zero when the string becomes horizontal during the subsequent motion of the combined mass. **(IIT-JEE 1997)**

Two Dimensional Relative Motion

Single Correct

25. A boat which has a speed of 5 km/h in still water crosses a river of width 1 km along the shortest possible path in 15 min. The velocity of the river water in km/h is **(IIT-JEE 1998)**

(*a*) 1 (*b*) 3 (*c*) 4 (*d*) $\sqrt{41}$

26. A river is flowing from West to East at a speed of 5 m/min. A man on the South bank of the river, capable of swimming at 10 m/min in still water, wants to swim across the river in the shortest time. He should swim in a direction **(IIT-JEE 1983)**

(*a*) Due North (*b*) 30° East of North

(*c*) 30° West of North (*d*) 60° East of North

Multiple Correct

27. Starting at time $t = 0$ from the origin with speed $1 ms^{-1}$, a particle follows a two-dimensional trajectory in the x-y plane so that its coordinates are related by the equation $y = \frac{x^2}{2}$. The x and y components of its acceleration are denoted by a_x and a_y. respectively. Then **C-4.54 W-0 UA-33.55 PC-61.91 (JEE Adv. 2020)**

(*a*) $a_x = 1\ ms^{-2}$ implies that when the particle is at the origin, $a_y = 1\ ms^{-2}$

(*b*) $a_x = 0$ implies $a_y = 1\ ms^{-2}$ at all times

(*c*) at $t = 0$. the particle's velocity points in the x-direction

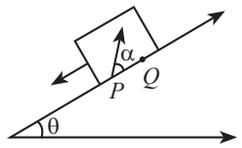
(*d*) $a_x = 0$ implies that at $t = 1s$, the angle between the particle's velocity and the x axis is 45°

Subjective

28. A large heavy box is sliding without friction down a smooth plane of inclination θ. From a point P on the bottom of the box, a particle is projected inside the box. The initial speed of the particle with respect to the box is u and the direction of projection makes an angle α with the bottom as shown in the figure. **(IIT-JEE 1984)**

(*a*) Find the distance along the bottom of the box between the point of projection P and the point Q where the particle lands (Assume that the particle does not hit any other surface of the box. Neglect air resistance.)

(*b*) If the horizontal displacement of the particle as seen by an observer on the ground is zero, find the speed of the box with respect to the ground at the instant when the particle was projected.



ANSWER KEY

JEE-Main

1. (*d*)	**2.** [673]	**3.** (*d*)	**4.** [2]	**5.** (*b*)	**6.** [580]	**7.** (*d*)	**8.** (*d*)	**9.** (*a*)	**10.** (*c*)
11. (*b*)	**12.** (*a*)	**13.** (*d*)	**14.** (Bonus)	**15.** (*a*)	**16.** [16]	**17.** (*b*)	**18.** (*c*)	**19.** (*b*)	**20.** (*a*)
21. (*a*)	**22.** (*b*)	**23.** (*a*)	**24.** (*d*)	**25.** (*c*)	**26.** (*c*)	**27.** [80]	**28.** [80]	**29.** (*d*)	**30.** (*d*)
31. (*a*)	**32.** (*b*)	**33.** (*c*)	**34.** (*d*)	**35.** (*d*)	**36.** (*d*)	**37.** (*b*)	**38.** [20]	**39.** [5]	**40.** [15or75]
41. (*c*)	**42.** (*c*)	**43.** [1]	**44.** (*b*)	**45.** (*a*)	**46.** (*c*)	**47.** (*b*)	**48.** (*d*)	**49.** [4.00]	**50.** [2]
51. [100]	**52.** (*b*)	**53.** (*a*)	**54.** (*b*)	**55.** [3]	**56.** [60]	**57.** (*c*)	**58.** (*c*)	**59.** (*a*)	**60.** [30]
61. [120]	**62.** [5]	**63.** (*d*)	**64.** (*d*)	**65.** (*a*)	**66.** [8]	**67.** (*a*)	**68.** [2]	**69.** (*b*)	**70.** [40]
71. [125]	**72.** (*b*)	**73.** (*a*)	**74.** (*b*)	**75.** [200]	**76.** (*a*)	**77.** (*d*)	**78.** (*c*)		

JEE-Advanced

1. (*b*)	**2.** (*a*, *b*, *c*)	**5.** (*c*)	**7.** (*a*)	**8.** (*a*)	**9.** [1/2]	**10.** [True]	**11.** (*d*)	**12.** [0.95]	**13.** [4.00]
15. [True]	**16.** [0.5]	**17.** [7.5]	**20.** (*b*)	**22.** [5]	**24.** (*b*)	**25.** (*a*)	**27.** (*a*, *b*, *c*, *d*)		