Motion in a Plane **Marks: 30**

ANSWER KEY

Physics

Q.1 C	Q.2 D	Q.3 B	Q.4 A	Q.5 C	Q.6 C	Q.7 A	Q.8 C
Q.9 B	Q.10 C	Q.11 C	Q.12 A	Q.13 D	Q.14 B	Q.15 C	Q.16 B
Q.17 D	Q.18 A	Q.19 D	Q.20 C	Q.21 A	Q.22 C	Q.23 B	Q.24 C
Q.25 B	Q.26 B	Q.27 B	Q.28 B	Q.29 A	Q.30 A		

Physics

Q.1 Four balls P, Q, R and S are thrown with equal velocities at angles of 10º, 30º, 45º and 60º respectively. Which ball will fall at the maximum distance?

Correct option: (C)

The range of a projectile is maximum when it is projected at an angle of 45°. Hence, ball R will travel the maximum distance.

Q.2 A body is falling freely under gravity. The distance covered by the body in first, second and third second of its motion are in the ratio

Correct option: (D)

When a body starts from rest and moves with uniform acceleration, distance covered by the body in n^{th} second is directly proportional to (2n – 1)

i.e., ratio of the distances covered in 1^{st} s, 2^{nd} s and 3^{rd} s is [2(1) – 1] : [2(2) – 1] : [2(3) – 1] = 1:3:5.

Q.3 A projectile has initially the same horizontal velocity as it would acquire if it had moved from rest with uniform acceleration of 4 m s^{-2} for half a minute. If the maximum height reached by it is 180 m, then the angle of projection is (Take g = 10 m s^{-2})

Correct option: (B) $\tan^{-1}(0.5)$

Maximum height, $H = \frac{u^2\sin^2\theta}{2g}$

$\therefore 180 = \frac{u^2\sin^2\theta}{2\times10} \Rightarrow u^2\sin^2\theta = 3600$

$u\sin\theta = 60\ m\ s^{-1}$

Horizontal velocity = $u\cos\theta$

As per question, $u\cos\theta = at$

$u\cos\theta = 4 \times 30 = 120\ m\ s^{-1}$

$\therefore \frac{u\sin\theta}{u\cos\theta} = \frac{60}{120} \Rightarrow \tan\theta = \frac{1}{2}$

$\therefore \theta = \tan^{-1}(0.5)$

Q.4 A body covers one-half of its journey at 40 m s^{-1} and the next half at 50 m s^{-1}. Its average velocity is

Correct option: (A)

$v = \frac{s}{\frac{s/2}{40}+\frac{s/2}{50}} = \frac{80\times100}{180} = 44.44\ m\ s^{-1}$

Q.5 Acceleration of a body when displacement equation is $3s = 9t + 5t^2$ is

Correct option: (C) $\frac{10}{3}$ m/s^2

$3s = 9t + 5t^2 \Rightarrow s = \frac{1}{3}(9t + 5t^2)$

Velocity = $\frac{ds}{dt} = \frac{1}{3}(9 + 10t)$

Acceleration = $\frac{d}{dt}\left(\frac{ds}{dt}\right) = \frac{d^2s}{dt^2} = \frac{10}{3}\ m/s^2$

Q.6 Body can NOT have

Correct option: (C)

Velocity is a vector quantity, meaning it has both magnitude (speed) and direction.

Constant velocity implies both speed and direction remain unchanged. Hence, having a constant velocity but variable speed is impossible.

Q.7 The trajectory of a projectile fired horizontally with velocity u is a parabola given by

Correct option: (A)

The trajectory of a projectile fired horizontally is a parabola.

The equation of the parabola is given by:

$$y = \left(\frac{g}{2u^2}\right)x^2$$

where: y is the vertical displacement, x is the horizontal displacement, g is the acceleration due to gravity, u is the initial horizontal velocity.

Therefore, the correct option is $y = \left(\frac{g}{2u^2}\right)x^2$.

Q.8 The angular separation between the minute hand and the hour hand of a clock at 12:20 pm is

Correct option: (C)

Degree moved by hour hand,

for 1 revolution = 360°

$$\text{for 1 hour} = \frac{360^\circ}{12} = 30^\circ$$

$$\text{for 1 min} = \frac{30}{60} = 0.5^\circ$$

$\therefore$ for 20 mins = 20 × 0.5° = 10°

Hence, at 12.20 pm

Angular separation = 120° – 10° = 110°

Q.9 The length of the string of a conical pendulum is 10 m and it has a bob of mass 50 g. The angle that the string makes with the vertical is 30°. If the bob covers one revolution in 3 s, then the corresponding centripetal force acting on the bob will be

Correct option: (B) 1 N

Using,

$r = l \sin\theta$

$r = 10 \sin 30° \Rightarrow r = 5$ m, $T = 3$ s

$\omega = \frac{2\pi}{T} = \frac{2\pi}{3}$

Centripetal force $= m\omega^2 r$

$= 5 \times 10^{-2} \times \frac{4\pi^2}{9} \times 5$

$= 25 \times 10^{-2} \times 4$

$= 100 \times 10^{-2} \approx 1$ N

Q.10 A shell fired from a canon can cover maximum horizontal distance of 10 km. Then velocity of projection is

Correct option: (C)

$R_{max} = \frac{u^2}{g}$

$\therefore u^2 = R_{max} \times g = 10 \times 10^3 \times 9.8$

$\therefore u = \sqrt{98,000}$ m/s

Q.11 The acceleration of a moving body can be found from

Correct option: (C)

Q.12 A man swims relative to water with a velocity greater than velocity of water. Then

Correct option: (A)

Self Explanatory!

Q.13 A local train, travelling at 72 km/hr is brought to rest in 10 seconds by applying the brake. How much is the acceleration produced in this case? Also how much is distance (s) covered by the train before coming to rest?

Correct option: (D) $a = -2$ m/s^2, $s = 100$ m

$u = 72$ km/hr $= \frac{72 \times 5}{18} = 20$ m/s

$v = u + at$

$0 = 20 + a \times 10$

$a = -2$ m/s^2

(negative sign indicates deceleration)

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

$= 20 \times 10 + \frac{1}{2} \times (-2) \times (10)^2$

$= 200 - 100$

$s = 100$ m

Q.14 A projectile is launched with an initial speed v_0 at an angle θ above the horizontal. At the instant when its velocity makes an angle of 45° with the horizontal, its speed is found to be half of its initial speed. The angle of projection θ is

Correct option: (B)

$v_x = v_0 \cos\theta$ (remains constant)

$v_y = v_0 \sin\theta - g\,t$

At the instant when the velocity makes an angle of 45°,

$v_x = v_y$

$v^2 = v_x^2 + v_y^2 = \left(\frac{v_0}{2}\right)^2$

Since $v_x = v_y$

$2\,v_x^2 = \frac{v_0^2}{4}$

$(v_0 \cos\theta)^2 = \frac{v_0^2}{8}$ …(Since $v_x = v_0 \cos\theta$)

$\cos\theta = \frac{\sqrt{2}}{4}$

Q.15 The speed v of a particle moving along a straight line, when it is at a distance x from a fixed point on the line is given by $v^2 = 108x - 9x^2$. Then magnitude of its acceleration when it is at a distance 3 metre from the fixed point is

Correct option: (C)

Acceleration of the particle, $a = \frac{dv}{dt}$

Now, $v^2 = 108x - 9x^2$

$\therefore$ Differentiating w.r.t t,

$2v\frac{dv}{dt} = 108\frac{dx}{dt} - 9 \times 2x\frac{dx}{dt}$

$\therefore 2av = 108v - 18xv$ [Since $v = \frac{dx}{dt}$]

$\therefore 2a = 108 - 18x$

$\therefore a = \frac{108 - 18 \times 3}{2}$

$a = 27$ m/s^2

Q.16 Two particles 'P' and 'Q' move in concentric circles of radii 'R_1' and 'R_2' respectively, in such a way that positions of particles P, Q and the centre of the circle 'O' always lie on a straight line and in the same plane. The ratio of the angular velocity of particle P to that of Q is

Correct option: (B)

Angular velocity of particle P,

$$\omega_P = \frac{v}{r_P} = \frac{v}{R_1}$$

Angular velocity of particle Q,

$$\omega_Q = \frac{v}{r_Q} = \frac{v}{r_2}$$

$$\frac{\omega_P}{\omega_Q} = \frac{v}{r_Q} \times \frac{R_2}{v}$$

$$\frac{\omega_P}{\omega_Q} = 1$$

Q.17 The trajectory of a projectile projected from origin is given by the equation y = x – $\frac{2x^2}{5}$. The initial velocity of the projectile is

Correct option: (D)

Comparing with $y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$

$\therefore \tan\theta = 1$

$\Rightarrow \theta = 45°$

$\frac{g}{2u^2\cos^2\theta} = \frac{2}{5}$

$\therefore \frac{10}{2u^2 \times \frac{1}{2}} = \frac{2}{5}$

$\therefore u^2 = \frac{50}{2} = 25$

$\therefore u = 5\ ms^{-1}$

Q.18 Assertion: The average velocity of the object over an interval of time is either smaller than or equal to the average speed of the object over the same interval.

Reason: Velocity is a vector quantity and speed is a scalar quantity.

Correct option: (A)

As displacement is either smaller or equal to distance but never be greater than distance.

Q.19 For a particle executing uniform circular motion, which one of the following is correct?

Correct option: (D)

Q.20 A stone is projected with velocity of 100 m/s at an angle of 60° with the horizontal, its maximum height is

Correct option: (C)

$H = \frac{u^2\sin^2\theta}{2g} = \frac{(100)^2 \times \sin^2 60°}{2 \times 9.8}$

$H \approx 382.6$ m

Q.21 The acceleration due to gravity on the planet A is 9 times the acceleration due to gravity on planet B. A man jumps to a height of 2 m on the surface of A. What is the height of jump by the same person on the planet B?

Correct option: (A)

$H_{max} = \frac{u^2}{2g}$

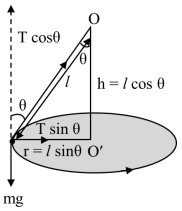
$H_{max} \propto \frac{1}{g}$

On planet B value of g is $\frac{1}{9}$ times to that of A. So value of H_{max} will become 9 times

$2 \times 9 = 18$ metre

Q.22 A string of length 'l' is fixed at one end and carries a mass 'm' at the other end. The mass is revolving along a horizontal circle of radius 'r' making 'θ' as the semi-vertical angle of cone and $\left(\frac{1}{\pi}\right)$ revolutions per second around the vertical axis through fixed end. The tension in the string is

Correct option: (C)



Given that, $f = \frac{1}{\pi}$ rps,

$\therefore \quad \omega = 2\pi f = 2\pi \times \frac{1}{\pi} = 2$ rad/s

In a conical pendulum, the centripetal force is provided by the horizontal component of the tension i.e., (Tsinθ).

$\therefore \quad T\sin\theta = mr\omega^2$

But $r = l\sin\theta$ and

$\omega^2 = 4$

$\therefore \quad T\sin\theta = m \times (l\sin\theta) \times 4$

$\therefore \quad T = 4ml$

Q.23 A stone is projected at an angle 60° to the horizontal. The ratio of kinetic energy of the stone at point of projection to its kinetic energy at highest point of flight will be (cos60° = 0.5)

Correct option: (B)

At projection:

speed = u ⇒ K.E.$_1$ = $\frac{1}{2}mu^2$

At highest point:

speed = $u\cos\theta$

⇒ KE$_2$ =

$$\frac{1}{2}m(u\cos\theta)^2 = \frac{1}{2}m\left(\frac{u}{2}\right)^2 = \frac{1}{8}mu^2$$

Ratio:

$$\frac{KE_1}{KE_2} = \frac{\frac{1}{2}mu^2}{\frac{1}{8}mu^2} = \frac{\frac{1}{2}}{\frac{1}{8}} = \frac{4}{1}$$

Q.24 In a car race, car A takes a time of t s less than car B at the finish and passes the finishing point with a velocity v m/s more than the car B. Assuming that the cars start from rest and travel with constant acceleration a_1 and a_2 respectively, velocity v is given by

Correct option: (C) $\sqrt{a_1a_2}\,t$

Let the time taken by two cars to complete the journey be t_1 and t_2 and their velocities at the finish be v_1 and v_2 respectively.

Given that, $t_1 = t_2 - t$ and $v_1 = v_2 + v$ ….(i)

At start, $u_1 = u_2 = 0$

$\therefore s_1 = s = \frac{1}{2}a_1t_1^2$

and $s_2 = s = \frac{1}{2}a_2t_2^2$ ….(ii)

Hence $a_1t_1^2 = a_2t_2^2 = 2s$

Also, $v_1 = a_1t_1$ and $v_2 = a_2t_2$

⇒ $v_1t_1 = a_1t_1^2 = 2s$ and $v_2t_2 = a_2t_2^2 = 2s$ ….(iii)

$\therefore t_1 = \frac{2s}{v_1}$ and $t_2 = \frac{2s}{v_2}$

So, $t_2 - t_1 = 2s\left[\frac{1}{v_2} - \frac{1}{v_1}\right]$ ….(iv)

From equations (i) and (iv)

$2s\left[\frac{1}{v_2} - \frac{1}{v_1}\right] = t$

$\therefore 2s\left[\frac{v_1 - v_2}{v_1v_2}\right] = t$

$2s\left[\frac{v}{v_1v_2}\right] = t$

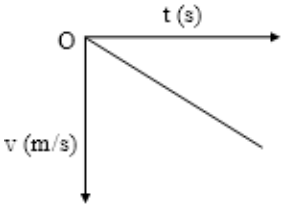
$\therefore v = \left[\frac{v_1v_2}{2s}\right]t = \sqrt{\frac{v_1^2v_2^2}{(2s)^2}} \times t$

From equation (iii)

$v = \sqrt{\left(\frac{v_1v_2}{t_1t_2}\right)} \times t = \sqrt{(a_1a_2)} \times t$

Q.25 The nature of graph drawn for a freely falling body with time on the x-axis and speed on the y-axis is (Assuming initial speed to be zero)

Correct option: (B)



Q.26 A body travelling along a straight-line path travels first half of the distance with a velocity 10.5 ms^{-1}. During the travel time of the second half of the distance, first half time is travelled with a velocity 14 ms^{-1} and the second half time is travelled with a velocity 21 ms^{-1}. Then the average velocity of the body during the journey is

Correct option: (B)

Time covered for first half of the distance,

$t_1 = \frac{s/2}{10.5} = \frac{s}{21}$

Let t_2 be the time for the second half of the journey,

$\frac{s}{2} = 14t_2 + 21t_2 = 35t_2$

$t_2 = \frac{s}{70}$

average velocity = $\frac{\text{Total distance}}{\text{Total time}}$

$= \frac{s}{t_1+2t_2}$

$= \frac{s}{\frac{s}{21}+\frac{2s}{70}}$

= 13.1 m/s

Q.27 Angular velocity of hour arm of a clock, in rad/s, is

Correct option: (B) $\frac{\pi}{21600}$

For an hour hand, T = 12 hr = 12 × 3600 s

$\omega = \frac{2\pi}{T} = \frac{2\pi}{12\times3600} = \frac{\pi}{21600}$ rad/s

Q.28 If car travelling at 58 km/h overtakes another car travelling at 40 km/h, the relative velocity of first car with respect to another car is

Correct option: (B)

Relative velocity of 1st car w.r.t 2nd car

$v_{12} = v_1 - v_2 = 58 - 40 = 18$ km/hr

Q.29 When the force acting on the object and the velocity of the object both are along the same line, it is called _____.
Correct option: (A)

The motion in which an object moves along a straight line is called *rectilinear motion*. In this type of motion, the force acting on the object and the velocity of the object both are along the same line, so the object moves in a straight line without changing direction.

Q.30 At any time 't', the co-ordinates of moving particle are $x = \mathrm{at}^2$ and $y = \mathrm{bt}^2$. The speed of the particle is
Correct option: (A)

x – component of velocity

$$v_x = \frac{dx}{dt} = \frac{d}{dt}\left(at^2\right) = 2at$$

y – component of velocity

$$v_y = \frac{dy}{dt} = \frac{d}{dt}\left(bt^2\right) = 2bt$$

Speed of the particle is the magnitude of the velocity v = $\sqrt{v_x^2 + v_y^2}$

$\therefore$ v = $\sqrt{(2at)^2 + (2bt)^2}$

= $\sqrt{4a^2t^2 + 4b^2t^2}$

= $2t\sqrt{a^2 + b^2}$

Speed of the particle is $2t\sqrt{a^2 + b^2}$