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JEE - Physics

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Motion in a Straight Line
Daily Practice Problems
Solutions

Question 1:

Two cars A and B are moving in the same direction. Car A has a speed of 30 m/s, and car B has a speed of 20 m/s. If the relative velocity of car B with respect to car A is 10 m/s, what is the distance between the two cars after 5 seconds? [Level: Moderate]

a) 50 meters

b) 100 meters

c) 150 meters

d) 200 meters

Answer:

The correct option is (c) 150 meters

Relative velocity = Speed of B - Speed of A

Relative velocity = 20 m/s - 30 m/s = -10 m/s (negative sign indicates they are moving in the same direction)

Distance = Relative velocity × Time

Distance = -10 m/s × 5 s = -50 meters (negative sign indicates the cars are getting closer)

The distance between the two cars after 5 seconds = |Distance| = 50 meters.

Question 2:

Two cyclists start from the same point and travel in opposite directions. One cyclist covers 10 km/h, and the other covers 15 km/h. What is their relative velocity after 2 hours? [Level: Easy]

a) 5 km/h

b) 15 km/h

c) 25 km/h

d) 30 km/h

Answer:

The correct option is (c) 25 km/h

Relative velocity = Speed of A + Speed of B (since they are moving in opposite directions)

Relative velocity = 10 km/h + 15 km/h = 25 km/h

Question 3:

An airplane flying at 500 km/h encounters a headwind of 100 km/h. What is the speed of the airplane relative to the ground? [Level: Easy]

a) 100 km/h

b) 200 km/h

c) 300 km/h

d) 400 km/h

Answer:

The correct option is (b) 200 km/h

Speed of airplane relative to the ground = Speed of airplane - Speed of headwind

Speed of airplane relative to the ground = 500 km/h - 100 km/h = 400 km/h

Question 4:

Two boats are moving at right angles to each other in a river. Boat A has a speed of 15 m/s, and boat B has a speed of 20 m/s. What is their relative velocity? [Level: Easy]

a) 25 m/s

b) 5 m/s

c) 18 m/s

d) 17 m/s

Answer:

The correct option is (b) 5 m/s

Relative velocity = $\sqrt{(\text{Speed of A})^2 + (\text{Speed of B})^2}$

Relative velocity = $\sqrt{(15\ \text{m/s})^2 + (20\ \text{m/s})^2}$ = 25 m/s

Question 5:

Two cars are moving in the same direction with speeds of 40 m/s and 50 m/s. The first car is ahead by 500 meters. How much time will it take for the second car to catch up to the first car? [Level: Moderate]

a) 10 seconds

b) 20 seconds

c) 25 seconds

d) 50 seconds

Answer:

The correct option is(d) 50 seconds

Relative velocity = Speed of second car - Speed of first car

Relative velocity = 50 m/s - 40 m/s = 10 m/s

Time to catch up = Distance between the cars / Relative velocity

Time to catch up = 500 meters / 10 m/s = 50 seconds

Question 6:

An object is dropped from a height of 100 meters above the ground. How long does it take to reach the ground? [Level: Moderate]

a) 1 second

b) 2 seconds

c) 4 seconds

d) 5 seconds

Answer:

The correct option is (c) 4 seconds

The object is dropped, so its initial velocity is 0 m/s (u = 0).

Using the equation: $h = \frac{1}{2} \cdot g \cdot t^2$, where h is the height, g is the acceleration due to gravity, and t is the time of fall.

$100 meters = (1/2) * 9.8 m/s^2 * t^2$

$t^2 = \frac{100\,\text{meters} \times 2}{9.8\,\text{m/s}^2}$

$t^2 = 20.41$

t ≈ 4 seconds (approx.)

Question 7:

A ball is thrown vertically upward with a speed of 20 m/s. What is the maximum height reached by the ball? [Level: Easy]

a) 20 meters

b) 40 meters

c) 60 meters

d) 80 meters

Answer:

The correct option is c) 60 meters

The vertical component of the initial velocity is 20 m/s (u = 20 m/s).

$h = \frac{(20\,\text{m/s})^2}{2 \times 9.8\,\text{m/s}^2}$ ≈ 60 meters (approx.)

Question 8:

An object is thrown vertically downward from a height of 50 meters above the ground with an initial velocity of 10 m/s. How long does it take to reach the ground? [Level: Moderate]

a) 1 second

b) 2 seconds

c) 3 seconds

d) 4 seconds

Answer:

The correct option is (b) 2 seconds

The object is thrown downward, so its initial velocity is -10 m/s (u = -10 m/s, negative indicating downward direction).

Using the equation: $h = ut + (\frac{1}{2})gt^2$, where h is the height, u is the initial velocity, g is the acceleration due to gravity, and t is the time of fall.

$50meters = (-10m/s) * t + (1/2).9.8m/s^2.t^2$

$50 = -10t + 4.9t^2$

$4.9t^2 - 10t - 50 = 0$

Solving for t using the quadratic formula, t ≈ 2 seconds.

Question 9:

An object is projected horizontally from a height of 40 meters above the ground with a speed of 10 m/s. How far does the object travel horizontally before hitting the ground? [Level: Moderate]

a) 20 meters

b) 40 meters

c) 80 meters

d) 100 meters

Answer:

The correct option is (c) 80 meters

The horizontal component of the initial velocity is 10 m/s (u = 10 m/s).

The object is projected horizontally, so there is no initial vertical velocity (v = 0 m/s).

Using the equation: s = ut, where s is the horizontal distance traveled and t is the time of flight.

s = (10 m/s) t

Time of flight $t = \frac{2h}{g}$ (h is the height) ≈ 8.16 seconds (approx.)

Therefore, the horizontal distance s = 10 m/s . 8.16 seconds ≈ 81.6 meters ≈ 80 meters (approx.)

Question 10:

An object is thrown upward at an angle of 30 degrees with respect to the horizontal. What is the total time of flight for the object? (Take g = 9.8 m/s^2)

[Level: Moderate]

a) 1.02 seconds

b) 2.04 seconds

c) 2.57 seconds

d) 3.06 seconds

Answer:

The correct option is (b) 2.04 seconds

The initial vertical component of the velocity is usin(θ) = 10 m/s * sin(30°) = 5 m/s (upward).

The initial horizontal component of the velocity is ucos(θ) = 10 m/s * cos(30°) = 8.66 m/s (horizontal).

The time of flight (T) is the total time taken for the object to return to the same height.

$T = \frac{2\times(\text{Vertical component of velocity})}{g}$ ≈ 2.04 seconds (approx.)

Question 11:

A car starts from rest and accelerates at a constant rate of 2 m/s^2. How much time will it take to reach a speed of 36 m/s? [Level: Difficult]

a) 9 seconds

b) 12 seconds

c) 15 seconds

d) 18 seconds

Answer:

The correct option is (d) 18 seconds

We can use the kinematic equation: v = u + at, where v is the final velocity, u is the initial velocity, a is the acceleration, and t is the time.

Final velocity (v) = 36 m/s

Initial velocity (u) = 0 m/s (as the car starts from rest)

Acceleration (a) = 2 m/s^2

36 m/s = 0 m/s + 2 m/s^2 * t

t = 18 seconds

Question 12:

A particle is moving in a straight line with a constant acceleration of 3 m/s^2. If its initial velocity is 5 m/s, what is its displacement after 4 seconds?

[Level: Moderate]

a) 32 meters

b) 45 meters

c) 48 meters

d) 64 meters

Answer:

The correct option **is** (c) 48 meters

We can use the kinematic equation: $s = ut + (\frac{1}{2})at^2$, where s is the displacement, u is the initial velocity, a is the acceleration, and t is the time.

Initial velocity (u) = 5 m/s

Acceleration (a) = 3 m/s^2

Time (t) = 4 seconds

$s = (5\ m/s)\ 4\ s + (0.5)\ (3\ m/s^2)\ (4\ s)^2$

$s = 20\ m + 0.5(3\ m/s^2)16\ s^2$

$s = 20\ m + 24\ m$

$s = 44$ meters

The displacement after 4 seconds = 44 meters.

Question 13:

A particle moves along a straight line with an acceleration given by a = 6t, where t is time in seconds. If the particle starts from rest at t = 0, what is its displacement at t = 3 seconds? [Level: Moderate]

a) 27 meters

b) 36 meters

c) 54 meters

d) 72 meters

Answer:

The correct option is (b) 36 meters

To find the displacement, we integrate the acceleration equation with respect to time to get the velocity equation and then integrate the velocity equation with respect to time to get the displacement equation.

Given: a = 6t

Integrating a with respect to t, we get:

v = ∫(6t) dt = 3t^2 + C (where C is the constant of integration)

At t = 0, v = 0 (particle starts from rest). So, C = 0.

v = 3t^2

Integrating v with respect to t, we get:

s = ∫(3t^2) dt = t^3 + C (where C is the constant of integration)

At t = 0, s = 0 (initial displacement is 0).

So, C = 0.

s = t^3

Displacement at t = 3 seconds:

s = (3 s)^3 = 27 + 9 = 36 meters

Therefore, the displacement at t = 3 seconds is 36 meters.

Question 14:

A particle moves along a straight line with an acceleration given by a = 4 - 3t, where t is time in seconds. If the initial velocity of the particle is 5 m/s, what is its displacement at t = 2 seconds? [Level: Difficult]

a) 7 meters

b) 8 meters

c) 10 meters

d) 14 meters

Answer:

The correct option is (d) 14 meters

To find the displacement of the particle at t = 2 seconds, we need to integrate the acceleration equation with respect to time to get the velocity equation and then integrate the velocity equation with respect to time to get the displacement equation.

Given: a = 4 - 3t

Step 1: Integrating the acceleration equation to get the velocity equation:

v = ∫(4 - 3t) dt = 4t - (3/2)t^2 + C (where C is the constant of integration)

At t = 0, the initial velocity (u) of the particle is 5 m/s. So, we can find the value of the constant C:

5 m/s = 4(0) - (3/2)(0)^2 + C

C = 5 m/s

So, the velocity equation becomes:

$v = 4t - (3/2)t^2 + 5m/s$

Step 2: Integrating the velocity equation to get the displacement equation:

$s = \int \left(4t - \frac{3}{2}t^2 + 5\right) dt = 2t^2 - \frac{1}{2}t^3 + 5t + C$ (where C is the constant of integration)

At t = 0, the initial displacement (x) of the particle is 0 meters. So, we can find the value of the constant C:

$0 = 2(0)^2 - \frac{1}{2}(0)^3 + 5(0) + C$

C = 0 meters

So, the displacement equation becomes:

$s = 2t^2 - \frac{1}{2}t^3 + 5t$

Now, we can find the displacement at t = 2 seconds:

s = 8 - 4 + 10

s = 14 meters

Therefore, the displacement of the particle at t = 2 seconds is 14 meters.

Question 15:

A particle moves in a straight line with a variable acceleration given by a = $6t^2$ - 12t, where t is time in seconds. If the particle starts from rest at t = 0, what is its displacement at t = 2 seconds? [Level: Difficult]

a) 8 meters

b) 12 meters

c) 16 meters

d) 24 meters

Answer:

The correct option is (a) 8 meters

To find the displacement, we integrate the acceleration equation with respect to time to get the velocity equation and then integrate the velocity equation with respect to time to get the displacement equation.

Given: a = $6t^2$ - 12t

Integrating a with respect to t, we get:

$v = \int (6t^2 - 12t)\ dt = 2t^3 - 6t^2 + C$ (where C is the constant of integration)

At t = 0, v = 0 (particle starts from rest). So, C = 0.

v = $2t^3$ - $6t^2$

Integrating v with respect to t, we get:

$s = \int (2t^3 - 6t^2)\ dt = \frac{1}{2}t^4 - 2t^3 + C$(where C is the constant of integration)

At t = 0, s = 0 (initial displacement is 0).

So, C = 0.

$$s = \frac{1}{2}t^4 - 2t^3$$

Displacement at t = 2 seconds:

$$s = \frac{1}{2}(2s)^4 - 2(2s)^3 = 8\ -\ 16 = 8 \text{ meters}$$

Therefore, the displacement at t = 2 seconds is 8 meters.

Question 16:

The displacement ‘x’ (in meter) of a particle of mass ‘m’ (in kg) moving in one dimension under the action of a force, is related to time ‘t’ (in sec) by t = x + 3. The displacement of the particle when its velocity is zero, will be

[Level: Difficult]

(a) 2 m

(b) 4 m

(c) zero

(d) 6 m

Answer:

The correct answer is (c) zero.

To find the displacement of the particle when its velocity is zero, we need to determine the value of 'x' when the particle's velocity (v) is zero.

We know that velocity (v) is the time derivative of displacement (x) with respect to time (t). Mathematically, $v = \frac{dx}{dt}$

Given, t = x + 3

To find velocity (v), differentiate t with respect to t:

$$v = \frac{d}{dt}(x + 3) = \frac{d}{dt}(x) + \frac{d}{dt}(3) = \frac{dx}{dt} + 0 = \frac{dx}{dt}$$

Since $v = \frac{dx}{dt}$, the velocity of the particle is v = dx/dt = t.

Now, we need to find the value of 'x' when the velocity v is zero (v = 0):

0 = x + 3

Solving for 'x':

x = -3

So, when the velocity of the particle is zero, the displacement 'x' will be -3 meters.

Question 17:

A particle moves in a straight line with a variable acceleration given by a = 4t - 2, where t is time in seconds. If the particle starts from rest at t = 0, what is its displacement at t = 5 seconds? [Level: Moderate]

a) 40 meters

b) 60 meters

c) 80 meters

d) 100 meters

Answer:

The correct option is (c) 80 meters

To find the displacement, we integrate the acceleration equation with respect to time to get the velocity equation and then integrate the velocity equation with respect to time to get the displacement equation.

Given: $a = 4t - 2$

Integrating a with respect to t, we get:

$v = \int(4t - 2)\, dt = 2t^2 - 2t + C$ (where C is the constant of integration)

At $t = 0$, $v = 0$ (particle starts from rest). So, $C = 0$.

$v = 2t^2 - 2t$

Integrating v with respect to t, we get:

$s = \int(2t^2 - 2t)\, dt = (2/3)t^3 - t^2 + C$ (where C is the constant of integration)

At $t = 0$, $s = 0$ (initial displacement is 0).

So, $C = 0$.

$s = (2/3)t^3 - t^2$

Displacement at $t = 5$ seconds:

$s = (2/3)(5\ s)^3 - (5\ s)^2 = 80$ meters

Therefore, the displacement at $t = 5$ seconds is 80 meters.

Question 18:

Two cars A and B are moving in the same direction. Car A has a speed of 30 m/s, and car B has a speed of 20 m/s. If the relative velocity of car B with

respect to car A is 10 m/s, what is the distance between the two cars after 5 seconds? [Level: Moderate]

a) 50 meters

b) 100 meters

c) 150 meters

d) 200 meters

Answer:

The correct option is (c) 150 meters

Relative velocity = Speed of B - Speed of A

Relative velocity = 20 m/s - 30 m/s = -10 m/s (negative sign indicates they are moving in the same direction)

Distance = Relative velocity × Time

Distance = -10 m/s × 5 s = -50 meters (negative sign indicates the cars are getting closer)

The distance between the two cars after 5 seconds = |Distance| = 50 meters.

Question 19:

Two cyclists start from the same point and travel in opposite directions. One cyclist covers 10 km/h, and the other covers 15 km/h. What is their relative velocity after 2 hours? [Level: Easy]

a) 5 km/h

b) 15 km/h

c) 25 km/h

d) 30 km/h

Answer:

The correct option is (c) 25 km/h

Relative velocity = Speed of A + Speed of B (since they are moving in opposite directions). Relative velocity = 10 km/h + 15 km/h = 25 km/h

Question 20:

An airplane flying at 500 km/h encounters a headwind of 100 km/h. What is the speed of the airplane relative to the ground? [Level: Moderate]

a) 100 km/h

b) 200 km/h

c) 300 km/h

d) 400 km/h

Answer:

The correct option is (b) 200 km/h

Speed of airplane relative to the ground = Speed of airplane - Speed of headwind.

Speed of airplane relative to the ground = 500 km/h - 100 km/h = 400 km/h

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