PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. A force $F = -40x$ acts on a mass of 1 kg. x is the position of the mass. If maximum speed of the mass is 4 m/s, find the amplitude. All parameters are in SI units.

(1) $\frac{1}{\sqrt{10}}$ m (2) $\frac{2}{\sqrt{10}}$ m

(3) $\frac{3}{\sqrt{10}}$ m (4) $\frac{4}{\sqrt{10}}$ m

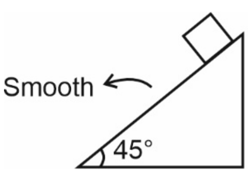
Answer (2)

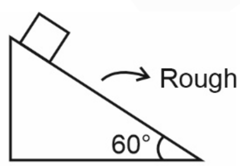
Sol. $V_{max} = A\omega = A\sqrt{\frac{k}{m}}$

$$\Rightarrow \quad 4 = A\sqrt{\frac{40}{1}}$$

$$\Rightarrow \quad A = \frac{2}{\sqrt{10}} \text{ m}$$

2. Consider 2 inclined plane of same height. 1st has a smooth surface and angle of inclination is 45°, other has a rough surface and angle of inclination is 60°. If ratio of time taken to slide on then its 'n'. Find coefficient of friction of rough inclined plane.





(1) $\mu = 3n^2$

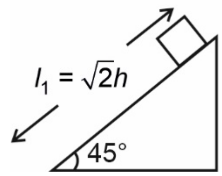
(2) $\mu = \frac{3-2n^2}{\sqrt{3}}$

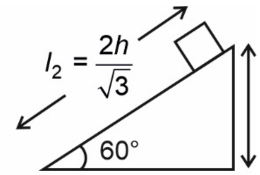
(3) $\mu = \frac{3-\sqrt{3}n^2}{2}$

(4) $\mu = \frac{2n^2}{\sqrt{3}}$

Answer (2)

Sol.





$a = g\sin\theta = \left(\frac{g}{\sqrt{2}}\right)$

$a = g\sin\theta - \mu g\cos\theta$

$= \left(g\frac{\sqrt{3}}{2} - \frac{\mu g}{2}\right)$

$= g\left(\frac{\sqrt{3}}{2} - \frac{\mu}{2}\right)$

$t_1 = \sqrt{\frac{2l_1}{a}} = \sqrt{\frac{2\sqrt{2}h}{\left(\frac{g}{\sqrt{2}}\right)}} = \sqrt{\frac{4h}{g}}$

$t_2 = \sqrt{\frac{2l_2}{a}} = \sqrt{\frac{2\times 2h}{\sqrt{3}g\left(\frac{\sqrt{3}}{2}-\frac{\mu}{2}\right)}} = \sqrt{\frac{8h}{g\left(3-\sqrt{3}\mu\right)}}$

$$\frac{t_1}{t_2} = \sqrt{\frac{3-\sqrt{3}\mu}{2}} = n$$

$$\Rightarrow 3-\sqrt{3}\mu = 2n^2$$

$$\Rightarrow \sqrt{3}\mu = 3-2n^2$$

$$\Rightarrow \mu = \left(\frac{3-2n^2}{\sqrt{3}}\right)$$

3. A particle undergoing uniform circular motion about origin. At certain instant $x = 2$ m and $v = -4\hat{j}$ m/s, find velocity and acceleration of particle when at $x = -2$ m.

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

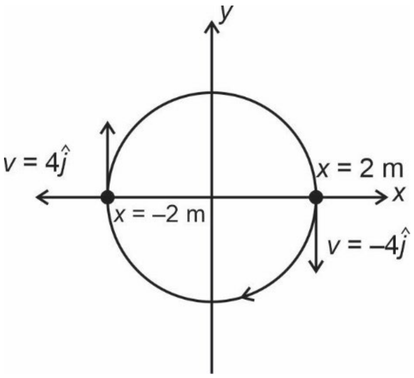
(2) $\vec{v} = 4\hat{j}$ m/s, $\vec{a} = 8\hat{i}$ m/s^2

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

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

Answer (2)

Sol. For uniform circular motion,



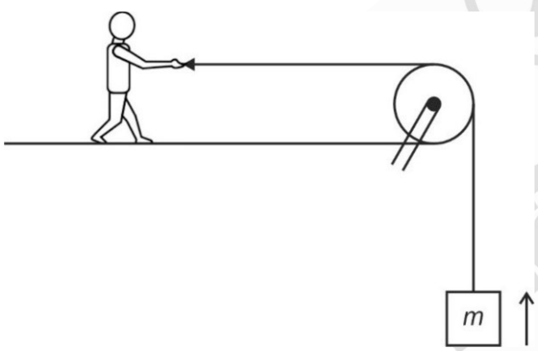
At $x = -2$ m, $v = 4\hat{j}$

$a = \left(\frac{v^2}{R}\right)$ towards the centre

$a = \left(\frac{4^2}{2}\right) = 8\ \text{m/s}^2$

$\vec{a} = 8\ \text{m/s}^2\left(\hat{i}\right)$

4. A man pulls a block as shown:



Consider the following statements:

(a) Work done by gravity on block is +ve

(b) Work done by gravity on block is -ve

(c) If man pulls block with constant speed, then tension in string equals weight of block.

(d) None of the above

Which of the statement(s) is/are correct?

(1) (b) & (c) only (2) (d) only

(3) (a) & (c) only (4) (a) only

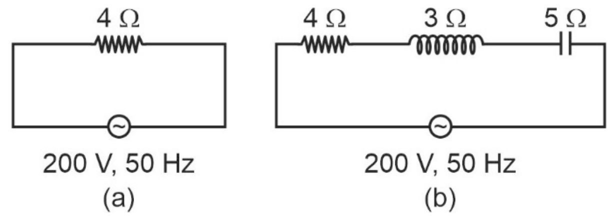
Answer (1)

Sol. Weight acts down and displacement is up ⇒ statement (b) is correct.

$T - mg = ma$

⇒ If $a = 0$, $T = mg$

5.



RMS current in circuit (a) is I_a while RMS current in circuit (b) is I_b then

(1) $I_a > I_b$ (2) $I_a < I_b$

(3) $I_a = I_b$ (4) None of the above

Answer (1)

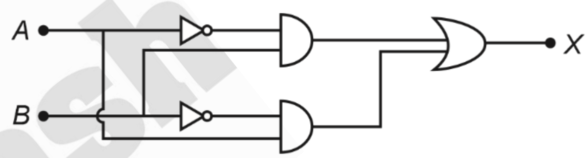
Sol. $Z_a = 4\ \Omega$ & $Z_a = \sqrt{4^2 + (5-3)^2}\,\Omega = \sqrt{20}\,\Omega$

$\Rightarrow\ I_a = \frac{220}{4}$ & $I_b = \frac{220}{\sqrt{20}}$

$= 55\ A$ $\quad = \frac{110}{\sqrt{5}}$

So $I_a > I_b$

6. Find truth table



(1)

A	B	X
0	0	1
0	1	1
1	0	1
1	1	0

(2)

A	B	X
0	0	1
0	1	0
1	0	0
1	1	1

(3)

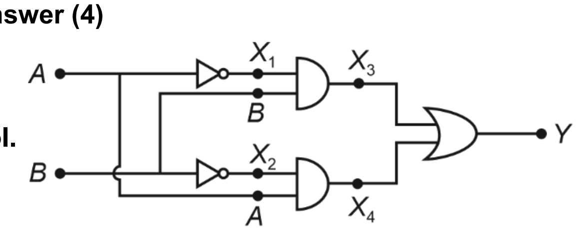
A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

(4)

A	B	X
0	0	0
0	1	1
1	0	1
1	1	0

Answer (4)

Sol.



$X_1 = \bar{A}$

$X_3 = B\cdot\bar{A}$

$X_2 = \bar{B}$

$X_4 = (A\bar{B})$

$Y = X_3 + X_4$

$= A\bar{B} + B\bar{A}$

Y = output = XOR gate

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

7. In a communication system, maximum voltage is 14 mV and minimum voltage is 6 mV. Find out the modulation index.

(1) 0.2 (2) 0.6

(3) 0.4 (4) 0.3

Answer (3)

Sol. Index $= \frac{V_{max} - V_{min}}{V_{max} + V_{min}} = \frac{14-6}{14+6} = 0.4$

8. The gravitational potential due to a solid uniform sphere of mass M and radius R at a point at radial distance r ($r > R$) from its centre is equal to

(1) $-\frac{GM}{r}$ (2) $-\frac{GM}{2r}$

(3) $-\frac{GMR}{r^2}$ (4) $-\frac{GM(R+r)}{r^2}$

Answer (1)

Sol. $E_{(r)} = \frac{GM}{r^2} \quad (r > R)$

$dV = -\vec{E} \cdot d\vec{r}$

$\int_V^0 dV = -\int_r^\infty \frac{GM}{r^2} dr$

$V = -\frac{GM}{r}$

9. Resolving power of compound microscope will increase with

(1) Decrease in wavelength of light and increase in numerical aperture

(2) Increase in wavelength of light and decrease in numerical aperture

(3) Increase in both wavelength and numerical aperture

(4) Decrease in both wavelength and numerical aperture

Answer (1)

Sol. Resolving power of microscope $\propto \left(\frac{2n\sin\theta}{\lambda}\right)$

n = Refractive index of the medium separating object and aperture.

$n\sin\theta$ = Numerical aperture

λ = wavelength of light used.

10. It is given that $x^2 + y^2 = a^2$, where a : radius. Also, it is given that $(x - \alpha t)^2 + \left(y - \frac{t}{\beta}\right)^2 = a^2$, where t = time. Then dimensions of α and β are

(1) $[M^0LT^{-1}]$ and $[M^0L^{-1}T]$

(2) $[M^0LT]$ and $[M^0L^{-1}T^{-1}]$

(3) $[M^0LT]$ and $[M^0LT^{-1}]$

(4) $[M^0L^{-1}T]$ and $[M^0LT]$

Answer (1)

Sol. $x \equiv \alpha t = \frac{t}{\beta}$

$\Rightarrow L' \equiv \alpha T' \equiv \frac{T'}{\beta}$

$\Rightarrow \alpha \equiv LT^{-1}$ and $\beta = L^{-1}T$

11. **Assertion (A):** EM waves are not deflected by electric field and magnetic field.

Reason (R): EM waves don't carry any charge so they are not deflected by electric field and magnetic field.

(1) Both (A) and (R) are true and (R) is correct explanation of (A)

(2) Both (A) and (R) are true, but (R) is not correct explanation of (A)

(3) (A) is true but (R) is false

(4) (A) is false but (R) is true

Answer (1)

Sol. EM wave does not have charge therefore they are not deflected by electric or magnetic field.

12. de-Broglie wavelength of a body of mass m and kinetic energy E is given by

(1) $\lambda = \frac{h}{mE}$ (2) $\lambda = \frac{\sqrt{2mE}}{h}$

(3) $\lambda = \frac{h}{\sqrt{2Em}}$ (4) $\lambda = \sqrt{\frac{h}{2mE}}$

Answer (3)

Sol. $E = \left(\frac{P^2}{2m}\right)$

where P is linear momentum, E = kinetic energy, m = mass of particle.

$P = \sqrt{2Em}$

$\lambda = \frac{h}{P} = \frac{h}{\sqrt{2Em}}$

13. In a region with electric field $30\hat{i}$ V/m a charge particle of charge $q = 2 \times 10^{-4}$ C is displaced slowly from (1, 2) to origin. The work done by the external agent is equal to

(1) 1 mJ (2) 6 mJ

(3) 2 mJ (4) 3 mJ

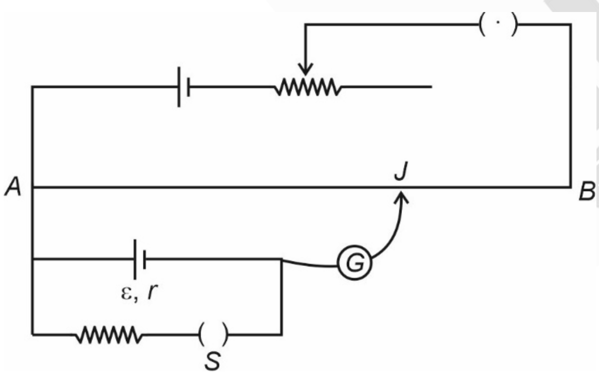
Answer (2)

Sol. $F = qE = 2 \times 10^{-4} \times 30$ N

Work done = $6 \times 10^{-3} \times (1)$ J = 6 mJ

14. Consider the following potentiometer circuit :

When switch S is open, length AJ is 300 cm. When switch S is closed, length AJ is 200 cm. If R 5 Ω, find internal resistance r of the cell.



(1) 4 Ω (2) 2 Ω

(3) 5 Ω (4) 2.5 Ω

Answer (4)

Sol. $C \times 300 = \varepsilon$ …(1)

$C \times 200 = \frac{\varepsilon}{R+r}R$ …(2)

$\Rightarrow \frac{300}{200} = \frac{R+r}{R}$

$\Rightarrow r = \frac{R}{2} = 2.5\ \Omega$

15.

16.

17.

18.

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. At 300 K, RMS speed of an ideal gas molecules is $\sqrt{\frac{\alpha+5}{\alpha}}$ times the average speed of gas molecules, then value of α is equal to $\left(\text{take } \pi = \frac{22}{7}\right)$

Answer (28.00)

Sol. $v_{rms} = \sqrt{\frac{3RT}{M_0}}$

$v_{av} = \sqrt{\frac{8RT}{\pi M_0}}$

$\frac{v_{rms}}{v_{av}} = \sqrt{\frac{3\pi}{8}}$

$= \sqrt{\frac{3 \times 22}{8 \times 7}}$

$= \sqrt{\frac{33}{28}} = \sqrt{\frac{28+5}{28}}$

$\Rightarrow \alpha = 28$

22. An α-particle and a proton are accelerated through same potential difference. The ratio of de-Broglie wavelength of alpha particle to proton is equal to $\frac{1}{\sqrt{x}}$. Value of x is (take $m_\alpha = 4m_{proton}$)

Answer (08.00)

Sol. $\lambda = \dfrac{h}{p}$

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mqV}}$$

$$\frac{\lambda_\alpha}{\lambda_p} = \sqrt{\frac{m_p q_p}{m_\alpha q_\alpha}} = \sqrt{\frac{1}{4} \times \frac{1}{2}} = \frac{1}{\sqrt{8}}$$

$\Rightarrow x = 8$

23. Time period of rotation of a planet is 24 hours. If the radius decreases to $\frac{1}{4}$th of original value, then the new time period is x hours. Find $2x$.

Answer (03.00)

Sol. $I\omega$ = constant

$$\Rightarrow \quad I_1\omega_1 = \frac{I_1}{16}\omega_2$$

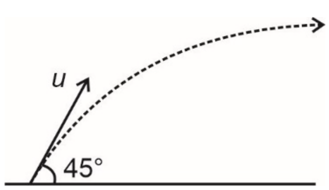
$$\Rightarrow \quad \omega_2 = 16\omega_1$$

$$\Rightarrow \quad T_2 = \frac{T_1}{16} = 1.5 \text{ hours}$$

24. A projectile is fire with velocity 54 km/hr making angle 45° with horizontal. Angular momentum of this particle of mass 1 kg about the point of projection one second into the motion will be $\frac{5N}{\sqrt{2}}$ in SI unit (g = 10 m/s^2). Find the value of N.

Answer (15.00)

Sol. u = 54 km/hr = 15 m/sec.



torque at time t is $\tau = mgu\cos\theta t$

$$\frac{dl}{dt} = \tau$$

$$\int_1^L dL = \int_0^1 mgu\cos\theta t dt$$

$$L = \frac{mgu\cos\theta}{2} = \frac{10 \times 15}{2\sqrt{2}} = \frac{75}{2} \text{ kg m}^2\text{/sec}$$

So N = 15

25. A block of mass 20 kg is moved with a constant force 'F' for 20 seconds starting from rest and then F is removed. It is then observed that block moves 50 m in next 10 seconds. Find F (in N).

Answer (05.00)

Sol. Impulse, $Ft = mv$

$$\Rightarrow \quad v = \frac{50}{10} = 5 \text{ m/s}$$

$F \times 20 = 20 \times 5 \Rightarrow F = 5$ N

26. Atomic mass number of a nuclei A is 16 and half life is 1 day. The values for a nuclei B are 32 and $\frac{1}{2}$ days. 320 grams each of A and B are taken initially. Find the ratio of their number of atoms after 2 days.

Answer (08.00)

Sol. $N_A = N_{0A}e^{-\lambda_A t}$

$$N_B = N_{0B}e^{-\lambda_B t}$$

$$\Rightarrow \quad \frac{N_A}{N_B} = \frac{N_{0A}}{N_{0B}}\frac{e^{-\lambda_A t}}{e^{-\lambda_B t}}$$

$$= \frac{\frac{320}{16}}{\frac{320}{32}} \times \frac{\frac{1}{4}}{\frac{1}{16}}$$

= 8

27.

28.

29.

30.