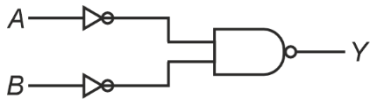
PHYSICS

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. The logical circuit shown below is equivalent to



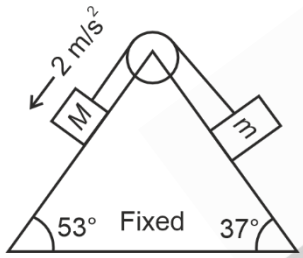
(1) NAND (2) NOR

(3) AND (4) OR

Answer (4)

Sol. Output, $Y = \overline{\overline{A}\cdot\overline{B}} = A + B$

2. The block M of mass 10 kg is having acceleration 2 m/s^2 in the direction shown. Find mass (m) of the other block.



(1) 2.5 kg (2) 7.5 kg

(3) 12.5 kg (4) 5 kg

Answer (3)

Sol. $a = \dfrac{(M\sin 53 - m\sin 37)g}{(M+m)}$

$m = \dfrac{15}{2}$ kg

3. If the percentage error in measuring length and diameter of a wire is 0.1% each, then the percentage error of the resistance of the wire is

(1) 0.3% (2) 0.2%

(3) 0.1% (4) 0.4%

Answer (1)

Sol. $R = \dfrac{\rho l}{A}$

$R = \dfrac{4\rho l}{\pi d^2}$

$\dfrac{\Delta R}{R} = \dfrac{\Delta l}{l} + 2\dfrac{\Delta d}{d}$

= 0.3 %

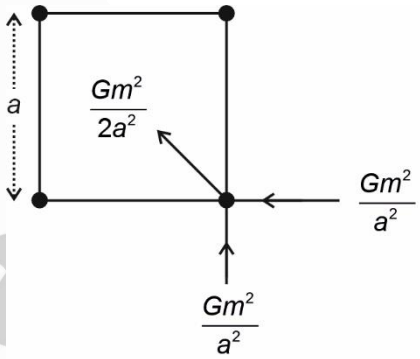
4. 4 identical particles of mass m each are placed at 4 corners of a square. The gravitational force exerted on one of the mass by other masses is $\left[\dfrac{2\sqrt{2}+1}{32}\right]\dfrac{Gm^2}{l^2}$. The distance of side of square is :

(1) $2l$ (2) $4l$

(3) $\dfrac{l}{2}$ (4) l

Answer (2)

Sol.



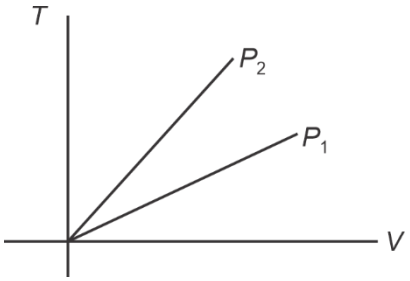
$\Rightarrow F_{Net} = \dfrac{Gm^2}{a^2}\left[\dfrac{1}{2}+\sqrt{2}\right]$

$= \dfrac{2\sqrt{2}+1}{2}\dfrac{Gm^2}{a^2}$

$\Rightarrow 2a^2 = 32l^2$

$\Rightarrow a = 4l$

5. $T - V$ graph is given for two different pressures P_1 & P_2. Then



(1) $P_2 > P_1$ (2) $P_1 = P_2$

(3) $P_2 < P_1$ (4) $P_2 \le P_1$

Answer (1)

Sol. $T - V$ graph: Straight line

$\Rightarrow$ Isobaric

Also, slope $\propto P$

$\Rightarrow P_2 > P_1$

6. For a 1 – D motion, relation between position x and time t is $t = \alpha x^2 + \beta x$. Find the relation between velocity v and acceleration a.

(1) $a = \alpha v$ (2) $a = -2\alpha v$

(3) $a = -2\alpha v^3$ (4) $a = 2\alpha v^2$

Answer (3)

Sol. $t = \alpha x^2 + \beta x$

$$\Rightarrow \frac{dt}{dx} = 2\alpha x + \beta = \frac{1}{v}$$

$$\Rightarrow v = \frac{1}{2\alpha x + \beta}$$

$$\text{Also, } a = \frac{vdv}{dx} = \frac{-1}{2\alpha x + \beta}\left[\frac{1}{2\alpha x + \beta}\right]^2 .2\alpha$$

$$\Rightarrow a = \frac{-2\alpha}{(2\alpha x + \beta)^3}$$

$$= -2\alpha v^3$$

$$\Rightarrow \boxed{a = -2\alpha v^3}$$

7. Two resistances having coefficient of variation of resistivity α_1 and α_2 are having equal resistance. Equivalent temperature coefficient of resistivity in series and parallel carburation are.

(1) $\frac{\alpha_1 + \alpha_2}{2}$, $\alpha_1 + \alpha_2$ (2) $\alpha_1 + \alpha_2$, $\alpha_1 + \alpha_2$

(3) $\alpha_1 + \alpha_2$, $\frac{\alpha_1 + \alpha_2}{2}$ (4) $\frac{\alpha_1 + \alpha_2}{2}$, $\frac{\alpha_1 + \alpha_2}{2}$

Answer (4)

Sol. $R_1 = R_0(1 + \alpha_1 T)$

$R_2 = R_0(1 + \alpha_2 T)$

$$\alpha_S = \frac{R_0(1+\alpha_1 T) + R_0(1+\alpha_2 T) - 2R_0}{2R_0 T}$$

$$\alpha_S = \frac{\alpha_1 + \alpha_2}{2}$$

$$\alpha_{||} = \frac{\frac{R_0(1+\alpha_1 T) + R_0(1+\alpha_2 T)}{2} - \frac{R_0}{2}}{\frac{R_0}{2}T}$$

$$\alpha_{||} = \frac{(\alpha_1 + \alpha_2)}{2}\frac{T}{T} = \frac{\alpha_1 + \alpha_2}{2}$$

8. An artillery of mass M_1, fires a shell of mass M_2. At the time of firing the ratio of kinetic energy is

(1) $\frac{M_2}{M_1}$

(2) $\frac{M_1 + M_2}{M_1}$

(3) $\frac{M_1 + M_2}{M_2}$

(4) $\frac{M_1}{M_1 + M_2}$

Answer (1)

Sol. By conservation of momentum

$P_1 = -P_2$

$$\frac{K_1}{K_2} = \frac{P_1^2}{2M_1} \times \frac{2M_2}{P_2^2} = \frac{M_2}{M_1}$$

9. The fundamental frequency of closed organ pipe is equal to the frequency of first overtone of open organ pipe of length 60 cm. The length of closed organ pipe is

(1) 45 cm

(2) 30 cm

(3) 15 cm

(4) 60 cm

Answer (3)

Sol. $\frac{V}{4L_1} = 2\left(\frac{V}{2L_2}\right)$

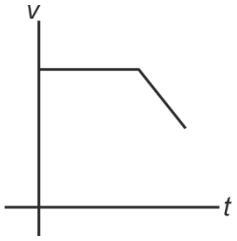
L_1 = Length of closed organ pipe

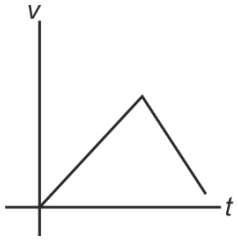
L_2 = Length of open organ pipe

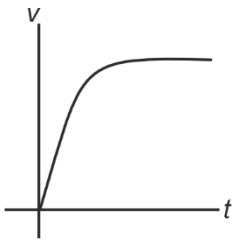
$L_2 = 4L_1$

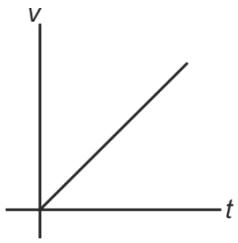
$$L_1 = \frac{L_2}{4} = 15 \text{ cm}$$

10. When a small spherical ball is dropped into a long cylindrical pipe filled with glycerine, then what will be the v versus t graph?

(1) 

(2) 

(3) 

(4) 

Answer (3)

Sol. $F = mg - B - 6\pi\eta rv$

Where B : Buoyancy

$$\Rightarrow \quad m\frac{dv}{dt} = \underbrace{(mg - B)}_{\text{constant}} - \underbrace{(6\pi\eta r)v}_{\text{constant}}$$

$$\Rightarrow \quad v = v_0\left[1 - e^{-ct}\right],\ c : \text{constant}$$

11. Force F depends on distance (x) and time(t) as $F = ax^2 + bt^{\frac{1}{2}}$, find dimension of $\frac{b^2}{a}$

(1) $M^1L^2T^{-3}$ (2) $M^1L^{-3}T^3$

(3) $M^1L^3T^{-3}$ (4) $M^2L^2T^1$

Answer (3)

Sol. From dimensional analysis

$$[a] = \frac{[F]}{\left[L^2\right]} = \frac{MLT^{-2}}{L^2} = \left[ML^{-1}T^{-2}\right]$$

$$[b] = \frac{[F]}{\left[T^{\frac{1}{2}}\right]} = \frac{MLT^{-2}}{T^{\frac{1}{2}}} = MLT^{\frac{-5}{2}}$$

Then dimension of $\frac{b^2}{a} = \frac{M^2L^2T^{-5}}{ML^{-1}T^{-2}}$

$$\left[\frac{b^2}{a}\right] = \left[ML^3T^{-3}\right]$$

12. Two charges q & $3q$ are placed at a distance r from each other. Find the distance from q where electric field is zero.

(1) $\frac{r}{\sqrt{3}+1}$ (2) $\frac{r}{2}$

(3) $\frac{r}{\sqrt{3}-1}$ (4) $\frac{2r}{3}$

Answer (1)

Sol. $\frac{kq}{x^2} = \frac{k\ 3q}{(r-x)^2}$

$$x = \frac{r-x}{\sqrt{3}}$$

$$x = \frac{r}{(\sqrt{3}+1)}$$

13. The refractive index of thin prism of an apex angle A is $\cot\left(\frac{A}{2}\right)$. Then the minimum angle of deviation is:

(1) $180° - 3A$ (2) $180° - 2A$

(3) $180° - A$ (4) $180° - 4A$

Answer (2)

Sol. $\delta_{min} = 2\sin^{-1}\left[\mu\sin\frac{A}{2}\right] - A$

$$= 2\sin^{-1}\left[\cos\frac{A}{2}\right] - A$$

$$= \pi - 2A$$

14. In single electron atom/ion, first member of Lyman series is λ, then wavelength of second member of this series shall be

(1) $\frac{5}{27}\lambda$ (2) $\frac{5}{32}\lambda$

(3) $\frac{27}{32}\lambda$ (4) $\frac{15}{23}\lambda$

Answer (3)

Sol. $\frac{1}{\lambda} = c\left\{1 - \frac{1}{4}\right\}$ for $2 \to 1$

$$\frac{1}{\lambda'} = c\left(1 - \frac{1}{9}\right) \text{ for } 3 \to 1$$

$$\frac{\lambda'}{\lambda} = \frac{3}{4} \times \frac{9}{8} = \frac{27}{32}$$

15. When light of wavelength λ is incident on a metal, the stopping potential is 8 V. If the wavelength is made 3λ the stopping potential becomes 2 V. Find the threshold wavelength for the photoelectric effect.

(1) 2.6×10^{-6} m

(2) 2.8×10^{-7} m

(3) 1.24×10^{-6} m

(4) 1.24×10^{-7} m

Answer (3)

Sol. $(8e) = \frac{hc}{\lambda} - \phi_0$ …(i)

$(2e)\ \frac{hc}{3\lambda} - \phi_0$ …(ii)

$\phi_0 = 1$ eV

$\therefore\ \lambda_{th} = 12400$ Å

$\lambda_{th} = 1.24 \times 10^{-6}$ m

16. In YDSE, intensity at two sources are in ratio of 1 : 9. If sources are coherent, then intensity at central point is I_1 and if sources are coherent (and phase differs by 60°), then intensity at central point is I_2, then $\frac{I_1}{I_2}$ is

(1) $\frac{10}{13}$

(2) $\frac{5}{13}$

(3) $\frac{8}{13}$

(4) $\frac{7}{11}$

Answer (1)

Sol. $I_1 = 1 + 9 = 10$

$I_2 = 1 + 9 + 2\sqrt{9}\cos 60° = 13$

$\frac{I_1}{I_3} = \frac{10}{13}$

17. Calculate the average energy density of an electromagnetic wave whose electric field is oscillating with amplitude 50 v/m and frequency 5×10^{10} Hz.

(1) 2×10^{-6} J/m^3

(2) 1.1×10^{-8} J/m^3

(3) 3×10^{-7} J/m^3

(4) 1.6×10^{-7} J/m^3

Answer (2)

Sol. Average energy density = $\frac{1}{2}\epsilon_0 E_0^2$

$= \frac{1}{2} \times 8.85 \times 10^{-12} \times 2500$

$= 1.106 \times 10^{-8}$ J/m^3

18.

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. A ball dropped from height H rebounds upto height h after colliding with horizontal surface. If coefficient of restitution for collision is $e = \frac{1}{2}$ then $\frac{H}{h}$ shall be

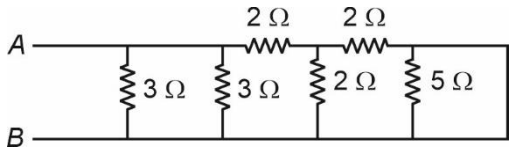
Answer (4)

Sol. **Defn** of $e = \frac{1}{2} = \frac{\sqrt{2gh}}{\sqrt{2gH}}$

$\frac{1}{4} = \frac{h}{H}$

$\Rightarrow\ 4$

22. Find equivalent resistance between A and B for given circuit in ohms.



Answer (1)

Sol. $\Rightarrow$ 5 is short circuited

$\Rightarrow$ 2, 2 are parallel $\Rightarrow$ 1

$\Rightarrow$ 1 & 2 in series = 3

$$R_{eq} = \frac{1}{3}(3) = 1\Omega$$

23. A uniform disk of mass 50 kg is rolling with speed of 0.4 m/s. Find minimum energy (in J) required to bring the disk to rest.

Answer (6)

Sol. $$KE = \frac{1}{2}mv_{\omega}^2 + \frac{1}{2}\left(\frac{mr^2}{2}\right)\omega^2$$

$$K = \frac{3}{4}mv^2$$

$$= \frac{3}{4} \times 50 \times (4) \times (0.4)$$

= 6 J

24. Mass defect in a nuclear reaction is 0.4 U. The Q value of the reaction is $\frac{x}{10}$ MeV, find x. Take 1 U = 930.5 MeV/c^2

Answer (372.2)

Sol. ϕ = [930.5 × 0.4 MeV/c^2] × c^2

= 372.2 MeV

25. At any instant, magnetic field inside a coil is 3000 T and it changes 2000 T in next 2 second. If average induced emf through coil is 22 Volt, then find number of turns of coil. (Area of turn is 2×10^{-3} m^2)

Answer (22)

Sol. From Faraday's law

Induced emf (e) $= -N\frac{d\Phi}{dt}$

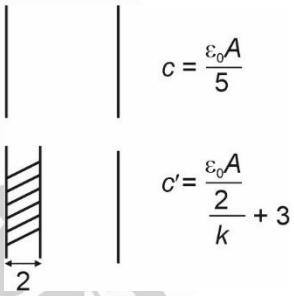
$$|22| = N\left|\frac{1000}{2}\right| \times 2 \times 10^{-3}$$

N = 22

26. A parallel plate capacitor with plates separated by 5 mm then it draws current of I_0 from AC source. Now a dielectric of thickness 2 mm is inserted between plates then current drawn increases by 25%. Find dielectric constant.

Answer (2)

Sol.



$i = \varepsilon_0 \omega c$

$i' = \varepsilon\omega c'$

$$\Rightarrow \frac{1}{1.25} = \frac{\frac{2}{k} + 3}{5}$$

$$\Rightarrow 5 = \frac{2.5}{k} + 3.75$$

$$\Rightarrow 1.25 = \frac{2.5}{k}$$

$\Rightarrow$ k = 2

27.

28.

29.

30.