PART : PHYSICS

Single Choice Type

This section contains **20 Single choice questions.** Each question has 4 choices (1), (2), (3) and (4) for its answer, out of which **Only One** is correct.

1. If weight of an object at pole is 196 N then weight at equator is [g = 10 m/s^2 ; radius of earth = 6400 Km]

(1) 194.32 N (2) 194.66 N (3) 195.32 N (4) 195.66 N

Ans. (3)

Sol. at pole, weight = mg = 196

m = 19.6 kg

at equator, weight = mg – mω^2R

$= 196 - (19.6)\left[\frac{2\pi}{24\times3600}\right]^2 \times 6400\times10^3$

= 195.33 N

2. In a house 15 Bulbs of 45 W, 15 bulbs of 100 W, 15 bulbs of 10 W and Two heaters of 1 KW each is connected to 220 V Mains supply then find minimum fuse current

(1) 5 A (2) 20 A (3) 25 A (4) 15 A

Ans. (2)

Sol. Total power is (15 × 45) + (15 × 100) + (15 × 10) + (2 × 1000)

= 4325 W

So current is = $\frac{4325}{220} = 19.66\,\text{A}$

Ans is 20 Amp.

3. In an adiabatic process, volume is doubled then find the ratio of final average relaxation time & initial relaxation time. Given $\frac{C_P}{C_V} = \gamma$

(1) $\frac{1}{2}$ (2) 2 (3) $\left(\frac{1}{2}\right)^{\gamma}$ (4) $\left(\frac{1}{2}\right)^{\frac{\gamma}{2}+1}$

Ans. (Bonus)

Sol. relaxation time $(\tau) \propto \frac{V}{\sqrt{T}}$

and $T \propto \frac{1}{V^{\gamma-1}}$

$\tau \propto V^{1+\frac{\gamma-1}{2}}$

$\tau \propto V^{\frac{1+\gamma}{2}}$

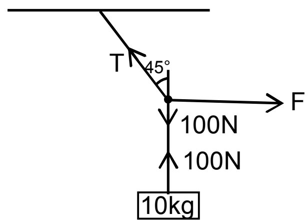
$\frac{\tau_f}{\tau_i} = \left(\frac{2V}{V}\right)^{\frac{1+\gamma}{2}}$; $\frac{\tau_f}{\tau_i} = (2)^{\frac{1+\gamma}{2}}$

4. A block of mass 10kg is suspended from string of length 4m. When pulled by a force F along horizontal from midpoint. Upper half of string makes 45° with vertical, value of F is

(1) 100N (2) 90N (3) 75N (4) 70N

Ans. (1)

Sol.



$\frac{T}{\sqrt{2}} = 100$

$\frac{T}{\sqrt{2}} = F$

F = 100N

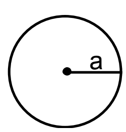
5. The surface mass density of a disc of radius a varies with radial distance as $\sigma = A + Br$ where A & B are positive constants then moment of inertia of the disc about an axis passing through its centre and perpendicular to the plane

(1) $2\pi a^4\left(\frac{A}{4}+\frac{Ba}{5}\right)$ (2) $2\pi a^4\left(\frac{Aa}{4}+\frac{B}{5}\right)$

(3) $\pi a^4\left(\frac{A}{4}+\frac{Ba}{5}\right)$ (4) $2\pi a^4\left(\frac{A}{5}+\frac{Ba}{4}\right)$

Ans. (1)

Sol.



$\sigma = A + Br$

$\int dm = \int (A+Br)2\pi r dr$

$I = \int dm\, r^2$

$= \int_0^a (A+Br)2\pi r^3 dr$

$= 2\pi\left(A\frac{a^4}{4}+B\frac{a^5}{5}\right)$

$= 2\pi a^4\left(\frac{A}{4}+\frac{Ba}{5}\right)$

6. Cascaded Carnot engine is an arrangement in which heat sink of one engine is source for other. If high temperature for one engine is T_1, low temperature for other engine is T_2 (Assume work done by both engine is same) Calculate lower temperature of first engine.

(1) $\frac{2T_1T_2}{T_1+T_2}$ (2) $\frac{T_1+T_2}{2}$ (3) 0 (4) $\sqrt{T_1T_2}$

Ans. **(2)**

Sol. Let, Q_H : Heat input to I^st engine

Q_L : Heat rejected from I^st engine

Q_L' : Heat rejected from II^nd engine

Work done by I^st engine = work done by II^nd engine

$Q_H - Q_L = Q_L - Q_L'$

$2Q_L = Q_H + Q_L'$

$2 = \frac{T_1}{T} + \frac{T_2}{T}$

$T = \frac{T_1+T_2}{2}$

7. Activity of a substance changes from 700 s^{-1} to 500 s^{-1} in 30 minute. Find its half-life in minutes

(1) 66 (2) 62 (3) 56 (4) 50

Ans. **(2)**

Sol. $\ell n\left[\frac{A_0}{A_t}\right] = \lambda t$

$\Rightarrow$ $\ell n2 = \lambda t_{1/2}$ …(i)

$\Rightarrow$ $\ell n\left[\frac{700}{500}\right] = \lambda(30\ \text{min})$ …(ii)

(i)/(ii)

$\Rightarrow$ $\frac{\ell n2}{\ell n(7/5)} = \frac{t_{1/2}}{(30\,\text{min})} \Rightarrow (2.06004)\ 30 = t_{1/2} = 61.8$ min.

8. In YDSE, separation between slits is 0.15 mm, distance between slits and screen is 1.5 m and wavelength of light is 589 nm, then fringe width is

(1) 5.9 mm (2) 3.9 mm (3) 1.9 mm (4) 2.3 mm

Ans. **(1)**

Sol. $\beta = \frac{\lambda D}{d} = \frac{589\times10^{-9}\times1.5}{0.15\times10^{-3}} = 5.9\,\text{mm}$

9. An ideal fluid is flowing in a pipe in streamline flow. Pipe has maximum and minimum diameter of 6.4 cm and 4.8 cm respectively. Find out the ratio of minimum to maximum velocity.

(1) $\frac{81}{256}$ (2) $\frac{9}{16}$ (3) $\frac{3}{4}$ (4) $\frac{3}{16}$

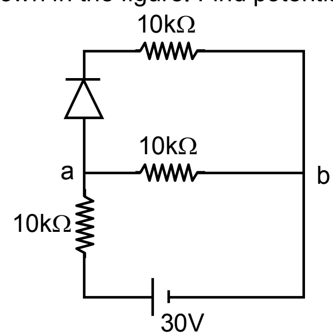
Ans. **(2)**

Sol. Using equation of continuity

$A_1V_1 = A_2V_2$

$$\frac{V_1}{V_2} = \frac{A_2}{A_1} = \left(\frac{4.8}{6.4}\right)^2 = \frac{9}{16}$$

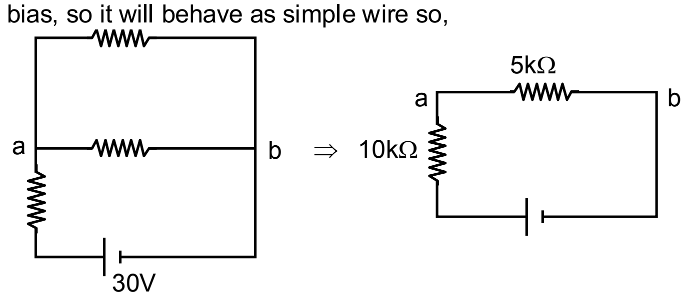
10. There is a electric circuit as shown in the figure. Find potential difference between points a and b.



(1) 0V (2) 15V (3) 10V (4) 5V

Ans. **(3)**

Sol. Diode is in forward bias, so it will behave as simple wire so,



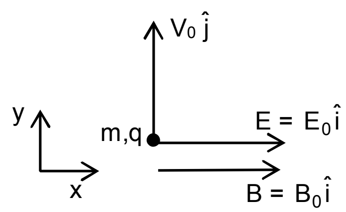
So, $V_{ab} = \frac{30}{5+10} \times 5 = 10V$

11. A particle of mass m and positive charge q is projected with a speed of v_0 in y–direction in the presence of electric and magnetic field are in x–direction. Find the instant of time at which the speed of particle becomes double the initial speed.

(1) $t = \frac{mv_0\sqrt{3}}{qE}$ (2) $t = \frac{mv_0\sqrt{2}}{qE}$ (3) $t = \frac{mv_0}{qE}$ (4) $t = \frac{mv_0}{2qE}$

Ans. **(1)**

Sol.



As $\vec{v} = v_0\hat{j}$ (magnitude of velocity does not change in y–z plane)

$(2v_0)^2 = v_0^2 + v_x^2$

$v_x = \sqrt{3}v_0$

$\therefore \sqrt{3}v_0 = 0 + \frac{qE}{m}t$

$t = \frac{mv_0\sqrt{3}}{qE}$

12. Two sources of sound moving with same speed v and emitting frequency of 1400 Hz are moving such that one source s_1 is moving towards the observer and s_2 is moving away from observer. If observer hears beat frequency of 2 Hz. Then find the speed of source. Given
$V_{sound} >> V_{Source}$
$V_{sound} = 350$ m/s

(1) $\frac{1}{4}$ (2) 4 (3) 2 (4) $\frac{1}{2}$

Ans. **(1)**

Sol.

$f_0\left(\frac{C}{C-V}\right) - f_0\left(\frac{C}{C+V}\right) = 2$

$V = \frac{1}{4}$ m/s

13. An electron & a photon have same energy E. Find the ratio of de Broglie wavelength of electron to wavelength of photon. Given mass of electron is m & speed of light is C.

(1) $\frac{1}{C}\left(\frac{E}{2m}\right)^{1/2}$ (2) $\left(\frac{E}{m}\right)^{1/2} C$ (3) $\frac{\sqrt{2mE}}{C}$ (4) $\left(\frac{E}{2m}\right)^{1/2}$

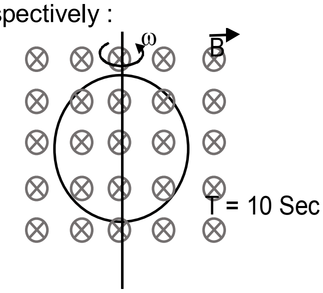
Ans. **(1)**

Sol. λ_d for electron = $\frac{h}{\sqrt{2mE}}$

λ for photon = $\frac{hC}{E}$

Ratio = $\frac{h}{\sqrt{2mE}} \frac{E}{hC} = \frac{1}{C}\sqrt{\frac{E}{2m}}$

14. A ring is rotated about diametric axis in a uniform magnetic field perpendicular to the plane of the ring. If initially the plane of the ring is perpendicular to the magnetic field. Find the instant of time at which EMF will be maximum & minimum respectively :



at t = 0

(1) 2.5 sec, 5 sec
(2) 5 sec, 7.5 sec
(3) 2.5 sec, 7.5 sec
(4) 10 sec, 5 sec

Ans. **(1)**

Sol. ∴ $\omega = \frac{2\pi}{T} = \frac{\pi}{5}$

When $\omega t = \frac{\pi}{2}$

∵ ϕ will be minimum.

∴ e will be maximum

$t = \frac{\frac{\pi}{2}}{\frac{\pi}{5}} = 2.5\,\text{sec}$

When $\omega t = \pi$

∵ ϕ will have maximum.

∵ e will be minimum.

$t = \frac{\pi}{\pi/5} = 5$ sec.

15. Electric field in space is given by $\vec{E}(t) = E_0 \frac{(\hat{i}+\hat{j})}{\sqrt{2}}$cos($\omega$t + Kz). A positively charged particle at (0, 0, π/K) is given velocity $v_0\hat{k}$ at t = 0. Direction of force acting on particle is

(1) f = 0

(2) Antiparallel to $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$

(3) Parallel to $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$

(4) $\hat{k}$

Ans. **(2)**

Sol. Force due to electric field is in direction $-\frac{(\hat{i}+\hat{j})}{\sqrt{2}}$

because at t = 0, $E = -\frac{(\hat{i}+\hat{j})}{\sqrt{2}} E_0$

Force due to magnetic field is in direction $q(\vec{v}\times\vec{B})$ and $\vec{v} \parallel \hat{k}$

$\therefore$ it is parallel to $\vec{E}$

$\therefore$ net force is antiparallel to $\frac{(\hat{i}+\hat{j})}{\sqrt{2}}$.

16. Focal length of convex lens in air is 16 cm (μ_{glass} = 1.5). Now the lens is submerged in liquid of refractive index 1.42. Find the ratio of focal length in medium to focal length in air has closest value

(1) 9 (2) 17 (3) 1 (4) 5

Ans. **(1)**

Sol.
$$\frac{1}{f_a} = \left(\frac{\mu_g}{\mu_a}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{f_m} = \left(\frac{\mu_g}{\mu_m}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\Rightarrow \frac{f_a}{f_m} = \frac{\left(\frac{\mu_g}{\mu_m}-1\right)}{\left(\frac{\mu_g}{\mu_a}-1\right)} = \frac{\left(\frac{1.50}{1.42}-1\right)}{\left[\frac{1.50}{1}-1\right]} = \frac{0.08}{(1.92)(0.5)}$$

$$\frac{f_m}{f_a} = \frac{(1.42)(0.5)}{0.08} = 8.875 \approx 9$$

17. A lift of mass 920 kg has a capacity of 10 persons. If average mass of person is 68 kg. Friction force between lift and lift shaft is 6000 N. The minimum power of motor required to move the lift upward with constant velocity 3 m/s is [g = 10 m/s^2]

(1) 66000 W (2) 63248 W (3) 48000 W (4) 56320 W

Ans. **(1)**

Sol. Net force on motor will be

F_m = [920 + 68(10)]g + 6000

= 22000 N

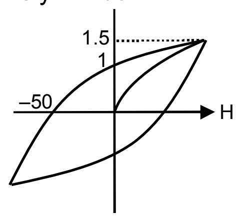
So, required power for motor

$P_m = \vec{F}_m . \vec{v}$

= 22000 x 3

= 66000 watt

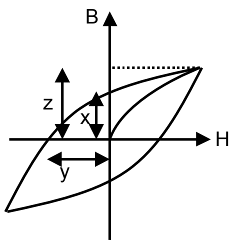
18. The hysteresis curve for a material is shown in the figure. Then for the material retentivity, coercivity and saturation magnetization respectively will be



(1) 50 A/m, 1T, 1.5 T
(2) 1.5 T, 50 A/m, 1T
(3) 1 T, 50 A/m, 1.5 T
(4) 50 A/m, 1.5 T, 1 T

Ans. **(3)**

Sol.



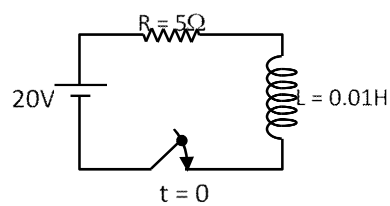
x = retentivity
y = coercivity
z = saturation magnetization

19. An inductor of inductance 10 mH and a resistance of 5Ω is connected to a battery of 20 V at t = 0. Find the ratio of current in circuit at t = ∞ to current at t = 40 sec.

(1) 1.06 (2) 1.48 (3) 1.15 (4) 0.84

Ans. **(1)**

Sol. $i = i_0\left(1 - e^{\frac{-t}{L/R}}\right)$



$= \frac{20}{5}\left(1 - e^{\frac{-t}{0.01/5}}\right) = 4(1 - e^{-500t})$

$i_\infty = 4$

$i_{40} = 4(1 - e^{-500 \times 40}) = 4\left(1 - \frac{1}{(e^2)^{10000}}\right) = 4\left(1 - \frac{1}{7.29^{10000}}\right)$

$\frac{i_\infty}{i_{40}} \approx 1$ slightly greater then one.

20. Find the dimension of $\frac{B^2}{2\mu_0}$

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

Ans. **(1)**

Sol. Energy density in magnetic field = $\frac{B^2}{2\mu_0}$

$= \frac{\text{Force} \times \text{displacement}}{(\text{displacement})^3} = \frac{MLT^{-2}.L}{L^3} = ML^{-1}T^{-2}$

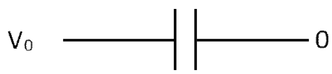
Numerical Value Type

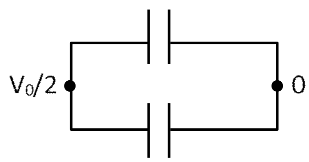
This section contains **5 Numerical value type questions.**

21. A capacitor of 60 pF charged to 20 volt. Now battery is removed and then this capacitor is connected to another identical uncharged capacitor. Find heat loss in nJ.

Ans. **6**

Sol.





$V_0 = 20$ V

Heat loss = $U_i - U_f$

$= \frac{1}{2}CV_0^2 - 2\left[\frac{1}{2}C\left(\frac{V_0}{2}\right)^2\right]$

$= \frac{CV_0^2}{4}$

$= \frac{(60 \times 10^{-12})(20)^2}{4}$ J

$= 6 \times 10^{-9}$ J = 6 nJ

22. When m gram of steam at 100°C is mixed with 200 gm of ice at 0°C. it results in water at 40°C. Find the value of m in gram .

(given : Latent heat of fusion (L_f) = 80 cal/gm, Latent heat of vaporisation (L_v) = 540 cal/gm., specific heat of water (C_w)= 1 cal/gm/°C)

Ans. **40**

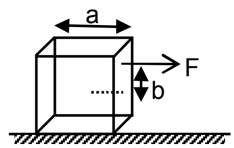
Sol. $M_{ice} L_f + m_{ice} (40 - 0) C_w = m_{steam}L_v + m_{steam}(100 - 40) C_w$

$\Rightarrow 200[80 + 40(1)] = m[540 + 60(1)]$

$\Rightarrow 200 (120) = m(600)$

m = 40 gm

23. A solid cube of side 'a' is shown in the figure. Find maximum value of $100\frac{b}{a}$ for which the block does not topple before sliding.



Ans. **50.00**

Sol. For no toppling

$$F\left(\frac{a}{2}+b\right) \le mg\frac{a}{2}$$

$$\mu\frac{a}{2}+\mu b \le \frac{a}{2}$$

$0.2a + 0.4b \le 0.5a$

$0.4b \le 0.3a$

$$b \le \frac{3a}{4}$$

$b \le 0.75a$ (in limiting case)

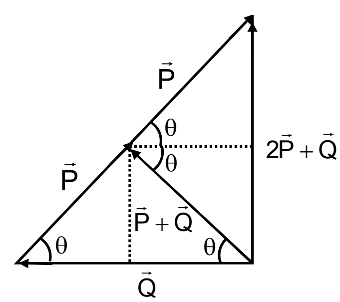
But it is not possible as b can maximum be equal to 0.5a

$$\therefore \quad \left(100\frac{b}{a}\right)_{max.} = 50.00$$

24. Magnitude of resultant of two vectors $\vec{P}$ and $\vec{Q}$ is equal to magnitude of $\vec{P}$. Find the angle between $\vec{Q}$ and resultant of $2\vec{P}$ and $\vec{Q}$.

Ans. **90°**

Sol. So angle between $(2\vec{P}+\vec{Q})$ and $\vec{Q}$ is 90°



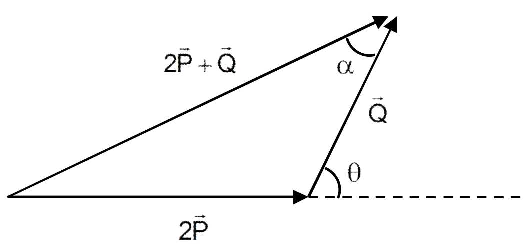
Alternate solution

$$\left|\vec{P}+\vec{Q}\right| = \left|\vec{P}\right|$$

$P^2 + Q^2 + 2PQ\cos\theta = P^2$

$\Rightarrow \quad Q + 2P\cos\theta = 0$

$$\Rightarrow \quad \cos\theta = -\frac{Q}{2P}$$



$$\tan\alpha = \frac{2P\sin\theta}{2P\cos\theta + Q} = \infty \qquad \because [2P\cos\theta + Q = 0]$$

$\alpha = 90°$

25. A battery of unknown emf connected to a potentiometer has balancing length 560 cm. If a resistor of resistance 10Ω is connected in parallel with the cell the balancing length change by 60 cm. If the internal resistance of the cell is $\frac{n}{10}$ Ω, the value of 'n' is

Ans. 12

Sol. Let the emf of cell is ε internal resistance is 'r' and potential gradient is x.

A/q only cell connected :

$\varepsilon = 560\ x$ ……(1)

After connecting the resistor

$\frac{\varepsilon \times 10}{10 + r} = 500x$ …..(2)

from (1) and (2)

$\frac{560 \times 10}{10 + r} = 500\ s$

56 = 50 + 5r

$r = \frac{6}{5} = 1.2\ \Omega$

n = 12