PART –A (PHYSICS)

***Questions*: 1**:- In the density measurement of a cube, the mass and edge length are measured as (10.00 ± 0.10) kg and (0.10 ± 0.01)m, respectively. The error in the measurement of density is:

(A) 0.10 kg/m^3 (B) 0.31 kg/m^3

(C) 0.07 kg/m^3 (D) 0.01 kg/m^3

***Ans*:- Bonus**

$\rho = \frac{m}{v}$

Maximum % error in ρ will be given by

$$\frac{\Delta p}{p} \times 100\% = \left(\frac{\Delta m}{m}\right) \times 100\% + 3\left(\frac{\Delta L}{L}\right) \times 100\% \quad \ldots(i)$$

This is not applicable as error is big.

$$\rho_{min} = \frac{m_{min}}{v_{max}} = \frac{9.9}{(0.11)^3} = 7438 \text{ kg/m}^3$$

$$\& \ \rho_{max} = \frac{m_{max}}{v_{min}} = \frac{10.1}{(0.09)^3} = 13854.6 \text{ kg/m}^3$$

Δp = 6416.6 kg/m^3

No option is matching. Therefore this question should be awarded bonus.

***Questions*: 2:-** The total number of turns and cross-section area in solenoid is fixed. However, its length L is varied by adjusting the separation between windings. The inductance of solenoid will be proportional to:

(A) 1/L (B) L

(C) 1/L^2 (D) L^2

***Ans*:- A**

ϕ = NBA = LI

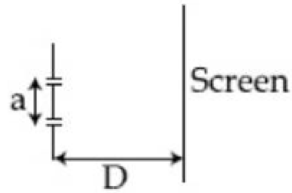
N μ_0 nIπR^2 = LI

$$N \mu_0 \frac{N}{\ell} I\pi R^2 = LI$$

N and R constant

$$\text{Self inductance (L)} \propto \frac{1}{\ell} \propto \frac{1}{\text{length}}$$

***Questions*: 3:-** The figure shows a Young's double slit experimental setup. It is observed that when a thin transparent sheet of thickness t and refractive index μ is put in front of one of the slits, the central maximum gets shifted by a distance equal to n fringe widths. If the wavelength of light used is λ, t will be:



(A) $\frac{2nD\lambda}{a(\mu-1)}$ (B) $\frac{nD\lambda}{a(\mu-1)}$

(C) $\frac{2D\lambda}{a(\mu-1)}$ (D) $\frac{D\lambda}{a(\mu-1)}$

Ans:- **D**

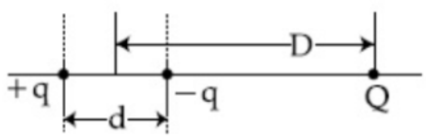
Path difference at central maxima $\Delta x = (\mu - 1)t$, whole pattern will shift by same amount which will be given by

$(\mu-1)t\frac{D}{d} = n\frac{\lambda D}{d}$, according to eh question $t = \frac{n\lambda}{(\mu-1)}$

No option is matching, therefore question should be award bonus.

$\therefore$ Correct option should be (Bonus)

Questions: **4:-** A system of three charges are placed as shown in the figure:



If D >> d, the potential energy of the system is best given by:

(A) $\frac{1}{4\pi\varepsilon_o}\left[-\frac{q^2}{d}-\frac{qQd}{D^2}\right]$ (B) $\frac{1}{4\pi\varepsilon_o}\left[-\frac{q^2}{d}-\frac{qQd}{2D^2}\right]$

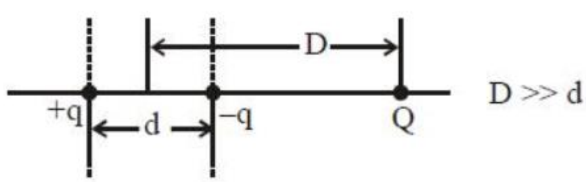
(C) $\frac{1}{4\pi\varepsilon_o}\left[-\frac{q^2}{d}+\frac{2qQd}{D^2}\right]$ (D) $\frac{1}{4\pi\varepsilon_o}\left[+\frac{q^2}{d}-\frac{qQd}{D^2}\right]$

Ans:- **D**

$U_{total} = U_{self\ of\ dipole} + U_{interaction}$

$= -\frac{kq^2}{d} - \left(\frac{kQ}{D^2}\right)qd$

$= -k\left[\frac{q^2}{d} + \frac{qQd}{D^2}\right]$



Questions: **5:-** A moving coil galvanometer has resistance 50 Ω and it indicates full deflection at 4mA current. A voltmeter is made using this galvanometer and a 5 kΩ resistance. The maximum voltage, that can be measured using this voltamenter, will be close to:

(A) 15 V (B) 20 V

(C) 10 V (D) 40 V

Ans:- **B**

$G = 50\ \Omega$
$S = 5000\ \Omega$
$I_g = 4 \times 10^{-3}$
$V = i_g (G + S)$
$V = 4 \times 10^{-3} (50 + 5000)$
$= 4 \times 10^{-3} (5050) = 20.2$ volt

***Questions*: 6:-** If 'M' is the mass of water that rises in a capillary tube of radius 'r', then mass of water which will rise in a capillary tube of radius '2r' is:

(A) 4 M (B) M/2
(C) M (D) 2 M

***Ans*:-D**

Height of liquid rise in capillary tube $h = \frac{2T\cos\theta_c}{\rho r g}$

$\Rightarrow h \propto \frac{1}{r}$

When radius becomes double height become half

$\therefore h' = \frac{h}{2}$

Now, $M = \pi r^2 h \times \rho$ and $M' = \pi(2r)^2 (h/2) \times \rho = 2M$.

***Questions*: 7:-** An NPN transistor is used in common emitter configuration as an amplifier with 1 kΩ load resistance. Signal voltage of 10 mV is applied across the base-emitter. This produces a 3 mA change in the collector current and 15μA change in the base current of the amplifier. The input resistance and voltage gain are:

(A) 0.67 kΩ, 300 (B) 0.67 kΩ, 200
(C) 0.33 kΩ, 1.5 (D) 0.33 kΩ, 300

***Ans*:-A**

Input current = 15×10^{-6}
Output current = 3×10^{-3}
Resistance out put = 1000
$V_{input} = 10 \times 10^{-3}$
Now $V_{input} = r_{input} \times i_{input}$
$10 \times 10^{-3} = r_{input} \times 15 \times 10^{-6}$

$r_{input} = \frac{2000}{3} = 0.67\ K\Omega.$

Voltage gain = $\frac{V_{output}}{V_{input}} = \frac{1000 \times 3 \times 10^{-3}}{10 \times 10^{-3}} = 300$

***Questions*: 8:-** An HCl molecule has rotational, translational and vibrational motions. If the rms velocity of HCl molecules in its gaseous phase is $\overline{v}$, m is its mass and k_B is Boltzmann constant, then its temperature will be:

(A) $\frac{m\overline{v}^2}{3k_B}$ (B) $\frac{m\overline{v}^2}{7k_B}$

(C) $\frac{m\overline{v}^2}{5k_B}$ (D) $\frac{m\overline{v}^2}{6k_B}$

Ans:- **A**

According to equipartion energy theorem

$$\frac{1}{2}m(v_{rms}^2) = 3 \times \frac{1}{2}K_bT$$

$$T = \frac{m\bar{v}_{rms}^2}{3k}$$

***Questions*:9:-**

The electric field of light wave is given as $\vec{E} = 10^{-3}\cos\left(\frac{2\pi x}{5\times10^{-7}} - 2\pi\times6\times10^{14}t\right)\hat{x}\frac{N}{C}$. This light falls on a metal plate of work function 2eV. The stopping potential of the photo-electrons is:

(A) 0.48 V (B) 2.48 V

(C) 0.72 V (D) 2.0 V

Ans:- **A**

$\omega = 6 \times 10^{14} \times 2\pi$

$f = 6 \times 10^{14}$

$C = f\lambda$

$\lambda = \frac{C}{f} = \frac{3\times10^8}{6\times10^{14}}$ = 5000 Å

Energy of photon $\Rightarrow \frac{12375}{5000}$ = 2.475 eV

From Einstein's equation

$KE_{max} = E - \phi$

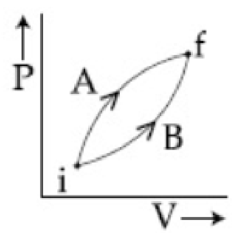
$eV_s = E - \phi$

$eV_s = 2.475 - 2$

$eV_o = 0.475$ eV

$V_o = 0.48$ V

***Questions*: 10:-** Following figure shows two processes A and B for a gas. If ΔQ_A and ΔQ_B are the amount of heat absorbed by the system in two cases, and ΔU_A and ΔU_B are changes in internal energies, respectively, then:



(A) $\Delta Q_A = \Delta Q_B$; $\Delta U_A = \Delta U_B$ (B) $\Delta Q_A > \Delta Q_B$; $\Delta U_A = \Delta U_B$

(C) $\Delta Q_A < \Delta Q_B$; $\Delta U_A < \Delta U_B$ (D) $\Delta Q_A > \Delta Q_B$; $\Delta U_A > \Delta U_B$

Ans:- **B**

Initial and final states for both the processes are same,

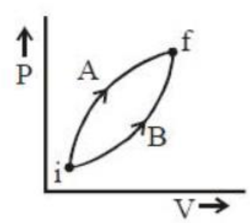
$\therefore \Delta U_A = \Delta U_B$

Work done during process A is greater than in process B. Because area is more

By First law of thermodynamics

$\Delta Q = \Delta U + W$

$\Rightarrow \Delta Q_A > \Delta Q_B$



***Questions*: 11:-** A uniform cable of mass 'M' and length 'L' is placed on a horizontal surface such that its $\left(\frac{1}{n}\right)^{th}$ part is hanging below the edge of the surface. To lift the hanging part of the cable upto the surface, the work done should be:

(A) nMgL (B) $\frac{MgL}{2n^2}$

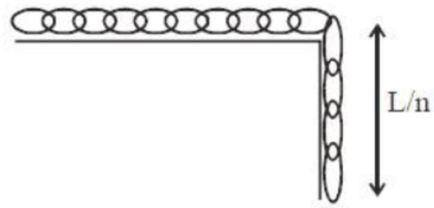
(C) $\frac{2MgL}{n^2}$ (D) $\frac{MgL}{n^2}$

***Ans*:-B**

Mass of the hanging part = $\frac{M}{n}$

$h_{COM} = \frac{L}{2n}$

Work done W = $mgh_{COM} = \left(\frac{M}{n}\right)g\left(\frac{L}{2n}\right) = \frac{MgL}{2n^2}$



***Questions*: 12:-** The following bodies are made to roll up (without slipping) the same inclined plane from a horizontal place: (i) a ring of radius R, (ii) a solid cylinder of radius R/2 and (iii) a solid sphere of radius R/4. If, in each case, the speed of the center of mass at bottom of the incline is same, the ratio of the maximum heights they climb is:

(A) 10 : 15 : 7 (B) 14: 15: 20

(C) 4 : 3 : 2 (D) 2 : 3 : 4

***Ans*:- B**

$\frac{1}{2}\left(m + \frac{1}{R^2}\right)v^2 = mgh$

If radius of gyration is k, then

$h = \frac{\left(1 + \frac{k^2}{R^2}\right)v^2}{2g}; \frac{k_{ring}}{R_{ring}} = 1, \frac{k_{solid\ cylinder}}{R_{solid\ cylinder}} = \frac{1}{\sqrt{2}}$

$\frac{k_{solid\ sphere}}{R_{solid\ sphere}} = \sqrt{\frac{2}{5}}$

$H_1 : h_2 : h_3 :: (1 + 1) : \left(1 + \frac{1}{2}\right) : \left(1 + \frac{2}{5}\right) :: 20 : 15 : 14$

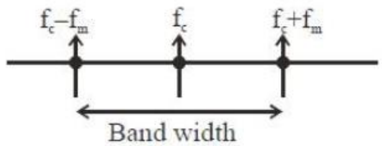
Therefore most appropriate option is (B)
Although which is not in correct sequence.

***Questions*: 13:-** A signal A cosωt is transmitted using v_0 sinω_0t as carrier wave. The correct amplitude modulated (AM) signal is:

(A) $v_0 \sin\left[\omega_0\left(1 + 0.01A\sin\omega t\right)t\right]$ (B) $v_0 \sin\omega_0 t + \frac{A}{2}\sin\left(\omega_0 - \omega\right)t + \frac{A}{2}\sin\left(\omega_0 + \omega\right)t$

(C) $v_0 \sin\omega_0 t + A\cos\omega t$ (D) $\left(v_0 + A\right)\cos\omega t \sin\omega_0 t$

***Ans*:- B**



***Questions*: 14:-** A concave mirror for face viewing has focal length of 0.4 m. The distance at which you hold the mirror from your face in order to see your image upright with a magnification of 5 is:

(A) 0.16 m (B) 1.60 m

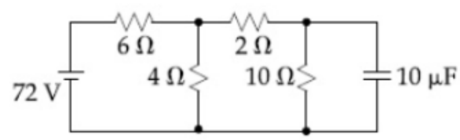
(C) 0.24 m (D) 0.32 m

***Ans*:- D**

$$m = \frac{f}{f-u}$$

$$5 = \frac{-40}{-40-u} \quad ; \quad u = -32 \text{ cm}$$

***Questions*: 15:-** Determine the charge on the capacitor in the following circuit:

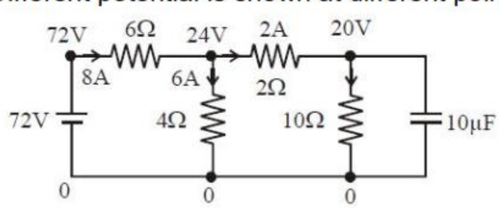


(A) 200 μC (B) 60 μC

(C) 10 μC (D) 2 μC

***Ans*:- A**

Different potential is shown at different points.



$q = eV$

$q = 10\mu F \times 20 = 200\ \mu C$

***Questions*: 16:-** A rectangular coil (Dimension 5 cm x 2 cm) with 100 100 turns, carrying a current of 3 A in the clock-wise direction, is kept centered at the origin and in the X-Z plane. A magnetic field of 1 T is applied along X-axis. If the coil is tilted through 45° about Z-axis, then the torque on the coil is:

(A) 0.42 Nm (B) 0.55 Nm

(C) 0.27 Nm (D) 0.38 Nm

***Ans*:- B**

$$|\vec{t}| = |\overline{M} \times \overline{B}|$$

$$\tau = NI \times A \times B \times \sin 45^\circ$$

$$\tau = 0.27 \text{ Nm}$$

***Questions*: 17:-** A stationary horizontal disc is free to rotate about its axis. When a torque is applied on it, its kinetic energy as a function of θ, where θ is the angle by which it has rotated, is given as $k\theta^2$. If its moment of inertia is I then the angular acceleration of the disc is:

(A) $\frac{k}{I}\theta$

(B) $\frac{k}{2I}\theta$

(C) $\frac{k}{4I}\theta$

(D) $\frac{2k}{I}\theta$

***Ans*:- D**

Kinetic energy KE = $\frac{1}{2}I\omega^2 = k\theta^2$

$$\Rightarrow \omega^2 = \frac{2k\theta^2}{I} \Rightarrow \omega = \sqrt{\frac{2k}{I}}\theta \qquad \ldots(A)$$

Differentiate (A) wrt time →

$$\frac{d\omega}{dt} = \alpha = \sqrt{\frac{2k}{I}}\left(\frac{d\theta}{dt}\right)$$

$$\Rightarrow \alpha = \sqrt{\frac{2k}{I}} \cdot \sqrt{\frac{2k}{I}}\theta \ \{\text{by (1)}\}$$

$$\Rightarrow \alpha = \frac{2k}{I}\theta$$

***Questions*: 18:-** A simple pendulum oscillating in air has period T. The bob of the pendulum is completely immersed in a non-viscous liquid. The density of the liquid is $1/6^{th}$ of the material of the bob. If the bob is inside liquid all the time, its period of oscillation in this liquid is**:**

(A) $2T\sqrt{\frac{1}{10}}$

(B) $2T\sqrt{\frac{1}{14}}$

(C) $4T\sqrt{\frac{1}{15}}$

(D) $4T\sqrt{\frac{1}{14}}$

***Ans*:- C**

For a simple pendulum T = $2\pi\sqrt{\frac{L}{g_{err}}}$

Situation 1: when pendulum is in air → g_{eff} = g

Situation 2:when pendulum is in liquid

$$\rightarrow g_{eff} = g\left(1 - \frac{\rho_{liquid}}{\rho_{body}}\right) = g\left(1 - \frac{1}{16}\right) = \frac{15g}{16}$$

$$\text{So, } \frac{T'}{T} = \frac{2\pi\sqrt{\frac{L}{15g/16}}}{2\pi\sqrt{\frac{L}{g}}}$$

$$\Rightarrow T' = \frac{4T}{\sqrt{15}}$$

***Questions*: 19:-** For a given gas at 1 atm pressure, rms speed of the molecules is 200 m/s at 127°C. At 2 atm pressure and at 227°C, the rms speed of the molecules will be:

(A) 80 m/s (B) $80\sqrt{5}$ m / s

(C) 100 m/s (D) $100\sqrt{5}$ m / s

***Ans*:- B**

$$V_{rms} = \sqrt{\frac{3RT}{M_w}}$$

$$\Rightarrow \quad v_{rms} \propto \sqrt{T}$$

$$\text{Now, } \frac{v}{200} = \sqrt{\frac{500}{400}} \Rightarrow \frac{v}{200} = \frac{\sqrt{5}}{2}$$

$$\Rightarrow \quad v = 100\sqrt{5}\text{ m/s}$$

***Questions*:20:-**

The magnetic field of a plane electromagnetic wave is given by:

$\vec{B} = B_0\hat{i}\left[\cos(kz - \omega t)\right] + B_1\hat{j}\cos(kz - \omega t)$ where $B_0 = 3 \times 10^{-5}$T and $B_1 = 2 \times 10^{-6}$T. The rms value of the force experienced by a stationary charge Q = 10^{-4}=C at z = 0 is closet to:

(A) 0.9 N (B) 0.6 N

(C) 0.1 N (D) 3 x 10^{-2}N

***Ans*:- D**

Maximum electric field E = (B) (C)

$$\vec{E}_0 = (3 \times 10^{-5})c\left(-\hat{j}\right)$$

$$\vec{E}_1 = (2 \times 10^{-6})c\left(-\hat{i}\right)$$

Maximum force

$$\vec{F}_{net} = 10^{-4} \times 3 \times 10^8\sqrt{(3 \times 10^{-5})^2 + (2 \times 10^{-6})^2} = 0.9\text{ N}$$

$$F_{rms} = \frac{F_0}{\sqrt{2}} = 0.6\text{ N} \quad \text{(approx)}$$