Physics (Paper A)
JEE MAIN 2013

***Questions*: 1:-** In an LCR circuit as shown below both switches are open initially. Now switch S_1 is closed, S_2 kept open. (q is charge on the capacitor and $\tau = RC$ is capacitive time constant). Which of the following statement is correct?

(A) At $t = \tau$, $q = CV/2$

(B) At $t = 2\tau$, $q = CV(1 - e^{-2})$

(C) At $t = \frac{\tau}{2}$, $q = CV(1 - e^{-1})$

(D) Work done by the battery is half of the energy dissipated in the resistor.

***Ans*:- (B)** Charge on the capacitor at any time 't' is

$q = CV(1 - e^{-t/\tau})$

at $t = 2\tau$

$q = CV(1 - e^{-2})$

***Questions*: 2:-** A diode detector is used to detect an amplitude modulated wave of 60% modulation by using a condenser of capacity 250 pico farad in parallel with a load resistance 100 kilo ohm. Find the maximum modulated frequency which could be detected by it.

(A) 10.62 kHz (B) 5.31 MHz

(C) 5.31 kHz (D) 10.62 MHz

***Ans*:- (C)**

$$f_C = \frac{1}{2\pi RC} = \frac{1}{2 \times 3.14 \times 100 \times 10^3 \times 250 \times 10^{-12}} = 6.37 \text{ kHz}$$

f_C = cut off frequency

As we know that f_m □ f_C

∴ (3) is correct

Note: The maximum frequency of modulation must be less than f_m, where

$$f_m = f_C \frac{\sqrt{1 - m^2}}{m}$$

m ⇒ modulation index

***Questions*: 3:-** The supply voltage to a room is 120 V. The resistance of the lead wires is 6 Ω. A 60 W bulb is already switched on. What is the decrease of voltage across the bulb, when a 240 W heater is switched on in parallel to the bulb?

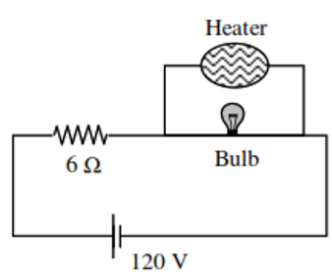
(A) 2.9 Volt (B) 13.3 Volt

(C) 10.04 Volt (D) zero volt

***Ans*:- (C)**

$$\text{Resistance of bulb} = \frac{120 \times 120}{60} = 240\Omega$$

$$\text{Resistance of Heater} = \frac{120 \times 120}{240} = 60\Omega$$



Voltage across bulb before heater is switched on, $V_1 = \frac{120}{246} \times 240$

Voltage across bulb after heater is switched on, $V_2 = \frac{120}{54} \times 48$

Decrease in the voltage is $V_1 - V_2 = 10.04$ (approximately)
Note: Here supply voltage is taken as rated voltage.

***Questions*: 4:-** A uniform cylinder of length L and mass M having cross-sectional area A is suspended, with its length vertical, from a fixed point by a massless spring, such that it is half submerged in a liquid of density σ at equilibrium position. The extension x_0 of the spring when it is in equilibrium is:

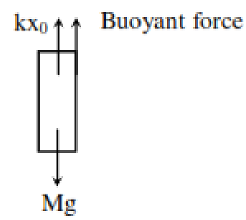
(A) $\frac{Mg}{k}\left(1 - \frac{LA\sigma}{M}\right)$ (B) $\frac{Mg}{k}\left(1 - \frac{LA\sigma}{2M}\right)$
(C) $\frac{Mg}{k}\left(1 + \frac{LA\sigma}{M}\right)$ (D) $\frac{Mg}{k}$

***Ans*:- (B)**

At equilibrium $\Sigma F = 0$

$$kx_0 + \left(\frac{AL}{2}\sigma g\right) - Mg = 0$$

$$x_0 = Mg\left[1 - \frac{LA\sigma}{2M}\right]$$



***Questions*: 5:-** Two charges, each equal to q, are kept at x = − a and x = a on the x-axis. A particle of mass m and charge $q_0 = \frac{q}{2}$ is placed at the origin. If charge q_0 is given a small displacement (y

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a) along the y-axis, the net force acting on the particle is proportional to:

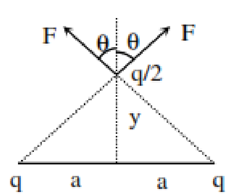
(A) – y (B) $\frac{1}{y}$
(C) $-\frac{1}{y}$ (D) y

***Ans*:- (D)**

$$F_{net} = 2F\cos\theta$$

$$= 2\frac{k \cdot q \cdot q/2}{\left(\sqrt{a^2 + y^2}\right)^2} \cdot \frac{y}{\sqrt{a^2 + y^2}}$$

$$= \frac{kq^2 y}{a^3}$$ (y □ a)

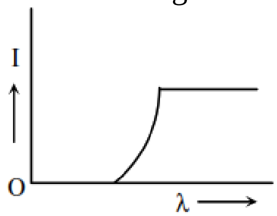


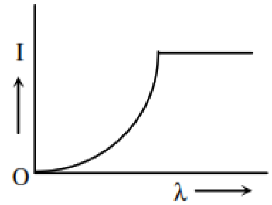
***Questions*: 6:-** A beam of unpolarised light of intensity I_0 is passed through a polaroid A and then through another polaroid B which is oriented so that its principal plane makes an angle of 45° relative to that of A. The intensity of the emergent light is:

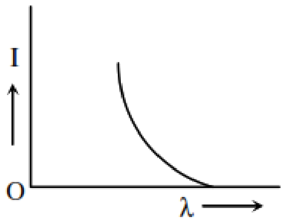
(A) $I_0/2$ (B) $I_0/4$
(C) $I_0/8$ (D) I_0

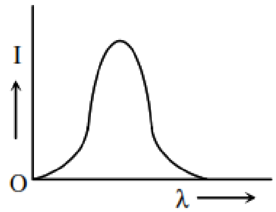
***Ans*:- (B)** $I_0/4$

***Questions*: 7:-** The anode voltage of a photocell is kept fixed. The wavelength λ of the light falling on the cathode is gradually changed. The plate current I of the photocell varies as follows:

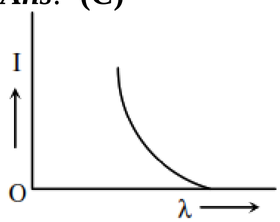
(A) 

(B) 

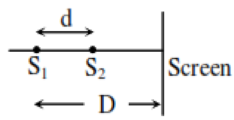
(C) 

(D) 

***Ans*:- (C)**



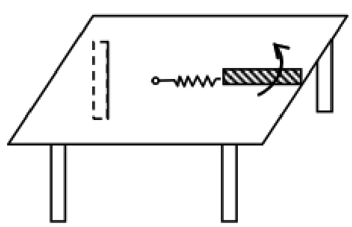
***Questions*: 8:-** Two coherent point sources S_1 and S_2 are separated by a small distance 'd' as shown. The fringes obtained on the screen will be:



(A) Straight lines
(B) Semi-circles
(C) Concentric circles
(D) Points

***Ans*:- (C)** Concentric circles

***Questions*: 9:-** A metallic rod of length $'\ell'$ is tied to a string of length 2ℓ and made to rotate with angular speed ω on a horizontal table with one end of the string fixed. If there is a vertical magnetic field 'B' in the region, the e. m. f. induced across the ends of the rod is:



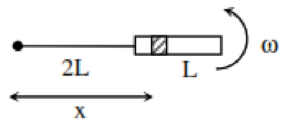
(A) $\frac{3B\omega\ell^2}{2}$
(B) $\frac{4B\omega\ell^2}{2}$
(C) $\frac{5B\omega\ell^2}{2}$
(D) $\frac{2B\omega\ell^2}{2}$

***Ans*:- (C)**

$$de = B(\omega x) \cdot dx$$

$$e = B\omega \int_{2L}^{3L} x dx$$

$$= \frac{5B\omega L^2}{2}$$



***Questions*: 10:-** In a hydrogen like atom electron makes transition from an energy level with quantum number n to another with quantum number (n – 1). If n >> 1, the frequency of radiation emitted is proportional to

(A) $\frac{1}{n^2}$ (B) $\frac{1}{n^{3/2}}$

(C) $\frac{1}{n^3}$ (D) $\frac{1}{n}$

***Ans*:- (C)**

$$\nu \propto \left[\frac{1}{(n-1)^2} - \frac{1}{n^2}\right]$$

$$\propto \frac{(2n-1)}{n^2(n-1)^2}$$

$$\propto \frac{1}{n^3} \quad (\text{since } n \gg 1)$$

***Questions*: 11:-** Assume that a drop of liquid evaporates by decrease in its surface energy, so that its temperature remains unchanged. What should be the minimum radius of the drop for this to be possible? The surface tension is T, density of liquid is ρ and L is its latent heat of vaporization.

(A) $\sqrt{T/\rho L}$ (B) T/ρL

(C) 2T/ρL (D) ρL/T

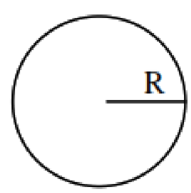
***Ans*:- (C)**

$$\rho 4\pi R^2 \Delta R L = T\, 4\pi[R^2 - (R - \Delta R)^2]$$

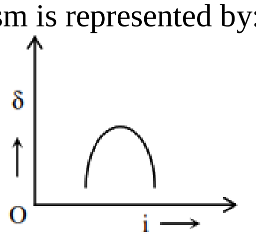
$$\rho R^2 \Delta R L = T[R^2 - R^2 + 2R\Delta R - \Delta R^2]$$

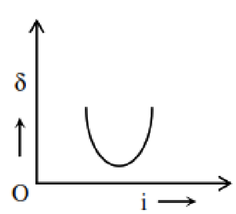
$$\rho R^2 \Delta R L = T 2R\Delta R \ (\Delta R \text{ is very small})$$

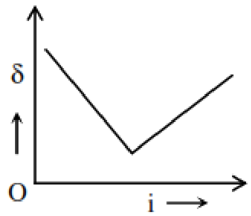
$$R = \frac{2T}{\rho L}.$$

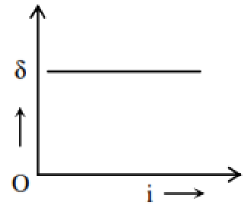


***Questions*: 12:-** The graph between angle of deviation (δ) and angle of incidence (i) for a triangular prism is represented by:

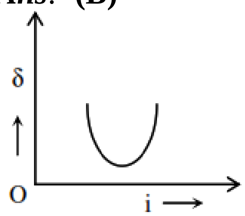
(A) 

(B) 

(C) 

(D) 

Ans:- **(B)**



***Questions*: 13:-** Let [ε_0] denote the dimensional formula of the permittivity of vacuum. If M = mass, L = length, T = time and A = electric current, then:

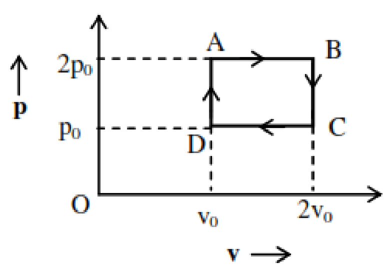
(A) [ε_0] = [$M^{-1}L^{-3}T^4A^2$]
(B) [ε_0] = [$M^{-1}L^2T^{-1}A^{-2}$]
(C) [ε_0] = [$M^{-1}L^2T^{-1}A$]
(D) [ε_0] = [$M^{-1}L^{-3}T^2A$]

Ans:- **(A)**

$$\frac{1}{4\pi\varepsilon_0}\frac{q^2}{r^2} = F$$

$$\varepsilon_0 = \frac{[A^2T^2]}{[MLT^{-2}L^2]} = [M^{-1}L^{-3}A^2T^4]$$

***Questions*: 14:-** The above p-v diagram represents the thermodynamic cycle of an engine, operating with an ideal monoatomic gas. The amount of heat extracted from the source in a single cycle is



(A) $\left(\frac{13}{2}\right) p_0v_0$
(B) $\left(\frac{11}{2}\right) p_0v_0$
(C) 4 p_0v_0
(D) p_0v_0

Ans:- **(B)** Heat is extracted from the source in path DA and AB is

$$\Delta Q = \frac{3}{2}R\left(\frac{P_0V_0}{R}\right) + \frac{5}{2}R\left(\frac{2P_0V_0}{R}\right) = \frac{13}{2}P_0V_0$$

***Questions*: 15:-** A sonometer wire of length 1.5 m is made of steel. The tension in it produces an elastic strain of 1 %. What is the fundamental frequency of steel if density and elasticity of steel are 7.7×10^3 kg/m^3 and 2.2×10^{11} N/m^2 respectively?

(A) 178.2 Hz
(B) 200.5 Hz
(C) 770 Hz
(D) 188.5 Hz

Ans:- **(A)**

Fundamental frequency $f = \frac{1}{2\ell}\sqrt{\frac{T}{\mu}}$

$= \frac{1}{2\ell}\sqrt{\frac{T}{A\rho}}$

$= \frac{1}{2\ell}\sqrt{\frac{\text{stress}}{\rho}} = \frac{1}{2\times1.5}\sqrt{\frac{2.2\times10^{11}\times10^{-2}}{7.7\times10^{3}}}$.

***Questions*: 16:-** This question has statement I and statement II. Of the four choices given after the statements, choose the one that best describes the two statements.

Statement- I: Higher the range, greater is the resistance of ammeter.

Statement- II: To increase the range of ammeter, additional shunt needs to be used across it.

(A) **Statement – I** is true, Statement – II is true, Statement – II is not the correct explanation of Statement–I.

(B) **Statement – I** is true, statement – II is false.

(C) **Statement – I** is false, Statement – II is true

(D) **Statement – I** is true, Statement – II is true, Statement – II is the correct explanation of statement- I.

***Ans*:- (C)** So for I to increase, S should decrease, so additional S can be connected across it.

For Ammeter, $S = \frac{I_g G}{I - I_g}$.

***Questions*: 17:-** What is the minimum energy required to launch a satellite of mass m from the surface of a planet of mass M and radius R in a circular orbit at an altitude of 2R?

(A) $\frac{2GmM}{3R}$ (B) $\frac{GmM}{2R}$

(C) $\frac{GmM}{3R}$ (D) $\frac{5GmM}{6R}$

***Ans*:- (D)** $T.E_f = -\frac{GMm}{6R}$

$T.E_i = -\frac{GMm}{R}$

$\Delta W = T.E_f - T.E_i = \frac{5GMm}{6R}$

***Questions*: 18:-** A projectile is given an initial velocity of $(\hat{i} + 2\hat{j})$ m/s, where $\hat{i}$ is along the ground and $\hat{j}$ is along the vertical. If g = 10 m/s^2, the equation of its trajectory is:

(A) $y = 2x - 5x^2$ (B) $4y = 2x - 5x^2$

(C) $4y = 2x - 25x^2$ (D) $y = x - 5x^2$

***Ans*:- (A)** x = t

$y = 2t - 5t^2$

Equation of trajectory is $y = 2x - 5x^2$

***Questions*: 19:-** Two capacitors C_1 and C_2 are charged to 120 V and 200 V respectively. It is found that by connecting them together the potential on each one can be made zero. Then:

(A) $3C_1 = 5C_2$ (B) $3C_1 + 5C_2 = 0$

(C) $9C_1 = 4C_2$ (D) $5C_1 = 3C_2$

***Ans*:- (A)** $120C_1 = 200C_2$

$6C_1 = 10C_2$

$3C_1 = 5C_2$

***Questions*: 20:-** A hoop of radius r and mass m rotating with an angular velocity ω_0 is placed on a rough horizontal surface. The initial velocity of the centre of the hoop is zero. What will be the velocity of the centre of the hoop when it ceases to slip?

(A) $\frac{r\omega_0}{3}$ (B) $\frac{r\omega_0}{2}$

(C) $r\omega_0$ (D) $\frac{r\omega_0}{4}$

***Ans*:- (B)** From conservation of angular momentum about any fix point on the surface

$$mr^2\omega_0 = 2mr^2\omega$$

$$\therefore \quad \omega = \frac{\omega_0}{2}$$

$$\therefore \quad V_{CM} = \frac{\omega_0 r}{2}$$