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JEE (Main)

PAPER-1 (B.E./B. TECH.)

2023

COMPUTER BASED TEST (CBT)
Questions & Solutions

Date: 24 January, 2023 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT: PHYSICS

Resonance Eduventures Ltd.

Reg. Office & Corp. Office : CG Tower, A-46 & 52, IPIA, Near City Mall, Jhalawar Road, Kota (Raj.) - 324005

Ph. No.: +91-744-2777777, 2777700 | **FAX No. :** +91-022-39167222

To Know more : sms **RESO** at **56677** | **Website :** www.resonance.ac.in | **E-mail :** contact@resonance.ac.in | **CIN :** U80302RJ2007PLC024029

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PART : PHYSICS

1. Given below are two Statements : one is labelled as **Assertion A** and the other is labelled as **Reason R**

Assertion A: Photodiodes are preferably operated in reverse bias condition for light intensity measurement

Reason R : The current in the forward bias is more than the current in the reverse bias for a p-n junction diode.

In the light of the above statement, choose the correct answer from the option given below:

(1) **A** is true but **R** is false

(2) Both **A** and **R** are true and **R** is the correct explanation of **A**

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

(4) Both **A** and **R** are true but **R** is **NOT** the correct explanation of **A**

Ans. **(4)**

2. A travelling wave is described by the equation y(x, t) = [0.05 sin(8x – 4t)]m The velocity of the wave is : [all the quantities are is SI unit]

(1) 4 ms^{-1} (2) 8 ms^{-1} (3) 0.5 ms^{-1} (4) 2 ms^{-1}

Ans. **(3)**

Sol. Compare the given equation with y = a sin(kx – ωt)

$k = 8, \omega = 4$

$\therefore$ Velocity (v) = $\frac{\omega}{k} = \frac{4}{8} = 0.5$ m/s

3. Two long straight wires P and Q carrying equal current 10 A each were kept parallel to each other at 5 cm distance. Magnitude of magnetic force experienced by 10 cm length of wire P is F_1. if distance between wires is halved and currents on them are doubled, force F_2 on 10 cm length of wire P will be:

(1)10 F_1 (2) 8F_1 (3) $\frac{F_1}{8}$ (4) $\frac{F_1}{10}$

Ans. **(2)**

Sol. $\frac{F_m}{\ell} = \frac{\mu_0 i_1 i_2}{2\pi d}$

$\Rightarrow \frac{F_m}{\ell} \propto \frac{(2)(2)}{(1/2)}$ = 8 times

$\therefore$ $F_2 = 8F_1$

4. Consider the following radioactive decay process

$$^{218}_{84}A \xrightarrow{\alpha} A_1 \xrightarrow{\beta^-} A_2 \xrightarrow{\gamma} A_3 \xrightarrow{\alpha} A_4 \xrightarrow{\beta^+} A_5 \xrightarrow{\gamma} A_6$$

The mass number and the atomic number of A_6 are given by:

(1) 211 and 80 (2) 210 and 80 (3) 210 and 82 (4) 10 and 84

Ans. **(2)**

Sol. $$^{218}_{84}A \xrightarrow{\alpha} {}^{218-4}_{82}A_1 \xrightarrow{\beta^-} {}^{218-4}_{83}A_2 \xrightarrow{\gamma} {}^{218-8}_{83}A_3 \xrightarrow{\alpha} {}^{218-8}_{81}A_4 \xrightarrow{\beta^+} {}^{218-8}_{80}A_5 \xrightarrow{\gamma} {}^{210}_{80}A_6$$

5. From the photoelectric effect experiment, following observations are made. Identify which of these are correct.

(A) The stopping potential depends only on the work function of the metal.

(B) The saturation current increases as the intensity of incident light increases.

(C) The maximum kinetic energy of a photo electron depends on the intensity of the incident light.

(D) Photoelectric effect can be explained using wave theory of light.

Choose the correct answer from the options given below:

(1) A, B, D only (2) B only (3) A, C, D only (4) B,C only

Ans. **(2)**

6. 1g of a liquid is converted to vapour at 3×10^5 Pa pressure. If 10% of the heat supplied is used for increasing the volume by 1600 cm^3 during this phase change, then the increase in internal energy in the process will be:

(1) 4800 J (2) 4320 J (3) 4.32×10^8J (4) 432000 J

Ans. **(2)**

Sol. $W = P\Delta V$

$= 3 \times 10^5 \times 1600 \times 10^{-6}$

$= 480$ J

10% of $Q = W$

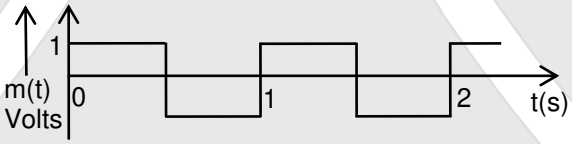
$Q = 4800$ J

$\Rightarrow \quad Q = \Delta U + W$

$\Delta U = Q - W$

$= 4800 - 480 = 4320$ J

7. A modulating signal is a square wave, as shown in the figure.



If the carrier wave is given as $c(t) = 2\sin(8\pi t)$ volts, the modulation index is:

(1) 1/3 (2) 1 (3) 1/2 (4) 1/4

Ans. **(3)**

Sol. $\mu = \frac{A_m}{A_c} = \frac{1}{2}$

8. Given below are two statement

Statement I : The temperature of a gas is –73°C. When the gas is heated to 527°C, the root mean square speed of the molecules is doubled.

Statement II : The product of pressure and volume of an ideal gas will be equal to translational kinetic energy of the molecules.

In the light of the above statements, choose the correct answer from the option given below:

(1) Statement I is false but Statement II is true (2) Both Statement I and Statement II are true

(3) Both Statement I and Statement II are false (4) Statement I is true but Statement II is false

Ans. **(4)**

Sol. **Statement -1 :** $V_{rms} = \sqrt{\frac{3RT}{M_0}}$

$$\frac{vr.m.s_1}{vr.m.s_2} = \sqrt{\frac{T_1}{T_2}} = \sqrt{\frac{200}{800}} = \frac{1}{2}$$

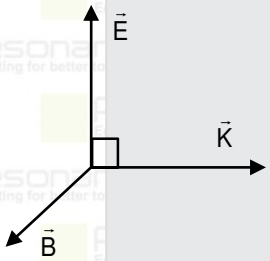
Statement -2 : $KE + = \frac{3}{2}PV$

9. In $\vec{E}$ and $\vec{K}$ represent electric field and propagation vectors of the EM waves in vacuum, then magnetic field vector is given by: (ω-angular frequency):

(1) $\frac{1}{\omega}\left(\vec{K}\times\vec{E}\right)$ (2) $\omega\left(\vec{K}\times\vec{E}\right)$ (3) $\vec{K}\times\vec{E}$ (4) $\omega\left(\vec{E}\times\vec{K}\right)$

Ans. **(1)**

Sol.



$\vec{K} \parallel \vec{E}\times\vec{B}$

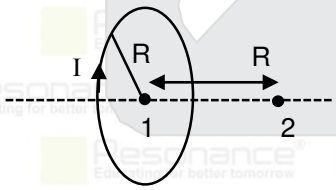
$\vec{K}\times\vec{E} \parallel \vec{B}$

10. A circular loop of radius r is carrying current IA. The ratio of magnetic field at the center of circular loop and at a distance r from the center of the loop on its axis is :

(1) $1:3\sqrt{2}$ (2) $2\sqrt{2}:1$ (3) $\sqrt{2}:2$ (4) $1:\sqrt{2}$

Ans. **(2)**

Sol.



$$B_1 = \frac{\mu_0 IR^2}{2R^3} = \frac{\mu_0 I}{2R}$$

on the axis at a distance R.

$$B_2 = \frac{\mu_0 IR^2}{2(R^2+R^2)^{3/2}} = \frac{\mu_0 IR^2}{2\times 2^{3/2}R^3} = \frac{\mu_0 I}{4\sqrt{2}R}$$

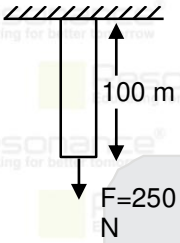
$$\frac{B_1}{B_2} = \frac{\mu_0 I}{2R}\times\frac{4\sqrt{2}R}{\mu_0 I} = 2\sqrt{2}$$

11. A 100 m long wire having cross-sectional area $6.25 \times 10^{-4} m^2$ and Young's modulus is 10^{10} Nm^{-2} is subjected to a load of 250 N, then the elongation in the wire will be:

(1) 6.25×10^{-3} m (2) 4×10^{-3} m (3) 4×10^{-4} m (4) 6.25×10^{-6} m

Ans. **(2)**

Sol.



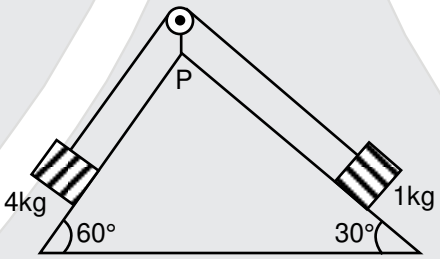
$$Y = \frac{F/A}{\Delta L/L}$$

$$\frac{F}{A} = Y\frac{\Delta L}{L} \quad ; \quad \Delta L = \frac{F \times L}{YA}$$

$$\Delta L = \frac{250 \times 100}{10^{10} \times 6.25 \times 10^{-4}} \Rightarrow \Delta L = \frac{250 \times 100}{625} \times 10^{-4}$$

$$\Delta L = 4 \times 10^{-3} \text{ m}$$

12. As per given figure, a weightless pulley P is attached on a double inclined frictionless surface. The tension in the string (massless) will be (if $g = 10$ m/s^2)



(1) $\left(4\sqrt{3}-1\right)$N (2) $4\left(\sqrt{3}-1\right)$N (3) $\left(4\sqrt{3}+1\right)$N (4) $4\left(\sqrt{3}+1\right)$N

Ans. **(4)**

Sol. $a = \frac{F_{net}}{m_1 + m_2}$

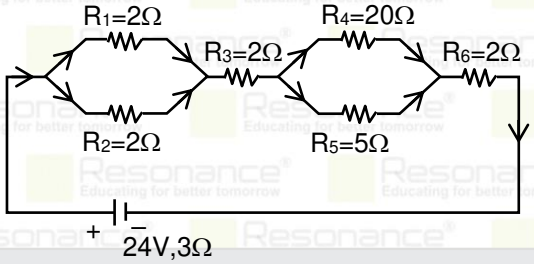
$$a = \frac{4g\sin 60° - 1g\sin 30°}{4+1} \Rightarrow a = \frac{4 \times 10 \times \frac{\sqrt{3}}{2} - 10 \times \frac{1}{2}}{5}$$

$$a = 4\sqrt{3} - 1 \text{ m/s}^2$$

$$T = 1.\,a + 1.g\sin 30° = 4\sqrt{3} - 1 + 10 \times \frac{1}{2}$$

$$T = 4(\sqrt{3}+1) \text{ N}$$

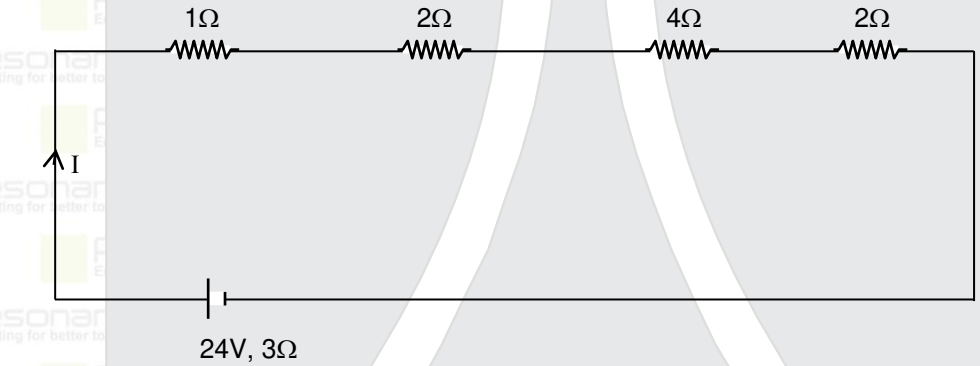
13. As shown in the figure, a network of resistors is connected to battery of 24 V with an internal resistance of 3Ω. The current through the resistors R_4 and R_5 are I_4 and I_5 respectively. The values of I_4 and I_5 are:

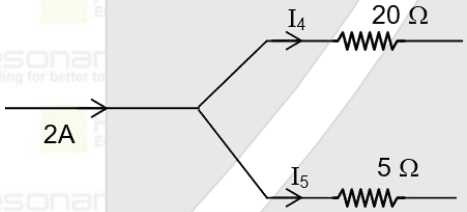


(1) $I_4 = \frac{8}{5}A$ and $I_5 = \frac{2}{5}A$ (2) $I_4 = \frac{6}{5}A$ and $I_5 = \frac{24}{5}A$ (3) $I_4 = \frac{2}{5}A$ and $I_5 = \frac{8}{5}A$ (4) $I_4 = \frac{24}{5}A$ and $I_5 = \frac{6}{5}A$

Ans. **(3)**

Sol.





$$I_4 = \frac{2}{(20+5)} \times 5 = \frac{2}{5}A$$

$$I_5 = \frac{2}{(20+5)} \times 20 = \frac{8}{5}A$$

14. Match **List I** with **List II**

	List I		**List II**
(A)	Plank's constant (h)	I.	$[M^1L^2T^{-2}]$
(B)	Stopping potential (Vs)	II.	$[M^1L^1T^{-1}]$
(C)	Work function (ϕ)	III.	$[M^1L^2T^{-1}]$
(D)	Momentum (p)	IV.	$[M^1L^2T^{-3}A^{-1}]$

Choose the correct answer from the options given below:

(1) A-II, B-IV, C-III, D-I (2) A-III, B-IV, C-I, D-II (3) A-I, B-III, C-IV, D-II (4) A-III, B-I, C-II, D-IV

Ans. **(2)**

Sol. $E = h\nu$

$$h = \frac{E}{\nu} = \frac{ML^2T^{-2}}{1/T} = \left[ML^2T^{-1}\right]$$

$$V_0 = \frac{W}{q} = \frac{ML^2T^{-2}}{AT} = [ML^2A^{-1}T^{-3}]$$

$\phi = w = [ML^2T^{-2}]$

$P = mv = [MLT^{-1}]$

15. Given below are two statement

Statement I : An elevator can go up or down uniform speed when its weight is balanced with the tension of its cable.

Statement II: Force exerted by the floor of an elevator on the foot a person standing on it is more than his/her weight when the elevator goes down with increasing speed.

In the light of the above statement, choose the correct from the options given below:

(1) Statement I is false but Statement II is true (2) Statement I is true but Statement II is false

(3) Both Statement I and Statement II are false (4) Both Statement I and Statement II are true

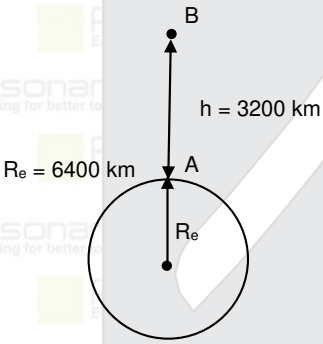
Ans. **(2)**

16. The weight of a body at the surface of earth is 18 N. The weight of the body at an altitude of 3200 km above the earth's surface is (given, radius of earth R_e = 6400 km)

(1) 19.6 N (2) 9.8 N (3) 4.9 N (4) 8 N

Ans. **(4)**

Sol.



$W_A = 18\ N, W_B = ?$

$$g_{eff} = \frac{g}{\left[1+\frac{h}{R}\right]^2} \Rightarrow \frac{4g}{9}$$

$$W_B = m \times \frac{4g}{9}$$

$$\frac{W_A}{W_B} = \frac{mg}{m \times \frac{4}{9}g} = \frac{18}{W_B} \Rightarrow W_B = \frac{4}{9} \times 18 = 8N$$

17. A conducting circular loop of radius $\frac{10}{\sqrt{\pi}}$ cm is placed perpendicular to a uniform magnetic field of 0.5 T. The magnetic field is decreased to zero in 0.5 sec at a steady rate. The induced emf in the circular loop at 0.25 s is :

(1) emf = 1 mV (2) emf = 100 mV (3) emf = 5 mV (4) emf = 10 mV

Ans. **(4)**

Sol. $\phi = BA = B(t) \times \pi \times \left(\frac{0.1}{\sqrt{\pi}}\right)^2$

$\phi(t) = B(t) \times 10^{-2}$

$EMF = \frac{d\phi}{dt} = (10^{-2})\frac{dB}{dt} = (10^{-2})\left(\frac{0.5}{0.5}\right)$

$EMF = 0.01 = 10$ mV

18. Given below are two statement:

Statement I : If the Brewster's angle for the light propagating from air to glass is θ_B, then the Brewster's angle for the light propagating from glass to air is $\frac{\pi}{2} - \theta_B$.

Statement II: The Brewster's angle for the light propagating from glass to air is $\tan^{-1}(\mu_g)$ where μ_g is the refractive index of glass.

In the light of the above statement, choose the correct answer from the option given below:

(1) Both Statement I and Statement II are true (2) Both Statement I and Statement II are false

(3) Statement I is true but Statement II is false (4) Statement I is false but Statement II is true

Ans. **(3)**

19. The maximum vertical height to which a man can throw a ball is 136 m. The maximum horizontal distance upto which he can throw the same ball is:

(1) 68 m (2) 136 m (3) 192 m (4) 272 m

Ans. **(4)**

Sol. $H_{max} = \frac{u^2}{2g} = 136$ m. $\Rightarrow$ $R_{max} = \frac{u^2}{g} = 136 \times 2 = 272$ m

20. If two charges q_1 and q_2 are separated with distance 'd' and placed in a medium of dielectric constant K. What will be the equivalent distance between charges in air for the same electrostatic force?

(1) $k\sqrt{d}$ (2) $1.5d\sqrt{d}$ (3) $2d\sqrt{k}$ (4) $d\sqrt{k}$

Ans. **(4)**

Sol. $F_1 = \frac{1}{4\pi\varepsilon_0 k}\frac{q_1q_2}{d^2}$ ...(1)

$F_2 = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{d'^2}$ ...(2)

(1) = (2)

$d'^2 = kd^2$

$d' = d\sqrt{k}$

21. A hole is drilled in a metal sheet. At 27°C, the diameter of hole is 5 cm. When the sheet is heated to 177°C, the change in the diameter of hole is d × 10^{-3} cm. The value of d will be_____if coefficient of linear expansion of the metal is 1.6 × 10^{-5} /°C.

Ans. **12**

Sol. as are know

$\Delta\ell = \ell_0\alpha\Delta T$

$\Delta d = d\alpha\Delta T = 5 \times 10^{-2} \times 1.6 \times 10^{-5} \times (177-27)$

$= 8 \times 10^{-7} \times 150 = 12 \times 10^{-5}$ m

$= 12 \times 10^{-3}$ cm

22. A spherical body of mass 2 kg starting from rest acquires a kinetic energy of 10000 J at the end of 5^{th} second. The force acted on the body is_____N.

Ans. **40**

Sol. Kinetic energy at t_5 = 1000 J

$\Rightarrow \frac{1}{2}mv^2 = 1000 \qquad \Rightarrow \frac{1}{2} \times 2 \times v^2 = 10000$

$v = 100$ m/s

$v = u + at$

$100 = 0 + a \times 5$

$a = 20$ m/s^2

$\frac{F}{m} = 20$

$F = 2 \times 20 = 40$ N

23. A hollow cylindrical conductor has length of 3.14 m, while its inner and outer diameters are 4 mm and 8 mm respectively. The resistance of the conductor is n × $10^{-3}\Omega$. If the resistivity of the material is 2.4 × 10^{-8} Ωm. The value of n is_____.

Ans. **(2)**

Sol. $R = \frac{\rho\ell}{A} = \frac{2.4\times10^{-8}\times3.14}{\pi(R_2^2 - R_1^2)}$

$= \frac{2.4\times10^{-8}}{(4+2)(4-2)\times10^{-6}} = 2 \times 10^{-3}\ \Omega$

24. Assume the proton and neutrons have equal masses. Mass of a nucleon is 1.6 × 10^{-27} kg and radius of nucleus is 1.5 × 10^{-15} $A^{1/3}$ m. The approximate ratio of the nuclear density and water density is n × 10^{13}. The value of n is _____.

Ans. **11**

Sol. Nuclear density = $\frac{\text{mass of nucleus}}{\text{volume of nucleus}}$

$= \frac{A\times amu}{v} = \frac{1.6\times10^{-27}\times A}{\frac{4}{3}\pi R_0^3 A} \qquad (R = R_0 A^{1/3})$

$= \frac{11.81\times10^{16}}{10^3} = 11.81 \times 10^3$

25. Vectors $a\hat{i}+b\hat{j}+\hat{k}$ and $2\hat{i}-3\hat{j}+4\hat{k}$ are perpendicular to each other when 3a + 2b = 7, the ratio of a and b is $\frac{x}{2}$ The value of x is_____.

Ans. **1**

Sol. Let $\vec{A}=a\hat{i}+b\hat{j}+\hat{k}$ and $\vec{B}=2\hat{i}-3\hat{j}+4\hat{k}$

$\vec{A}\perp\vec{B}$ $\quad\vec{A}.\vec{B}=0$

$$(a\hat{i}+b\hat{j}+\hat{k}).(2\hat{i}-3\hat{j}+4\hat{k})=0$$

$$2a-3b+4=0$$

$$2a-3b=-4 \quad \ldots(i)$$

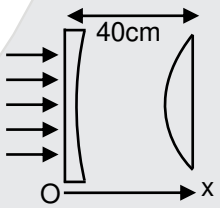
$$3a+2b=7 \quad \ldots(ii)$$

after solving we get,

$$a=1 \text{ and } b=2$$

$$\Rightarrow \quad \frac{a}{b}=\frac{1}{2}=\frac{x}{2} \quad \Rightarrow \quad x=1$$

26. As shown in the figure, a combination of a thin plano concave lens and a thin plano convex lens is used to image an object placed at infinity. The radius of curvature of both the lenses is 30 cm and refraction index of the material for both the lenses is 1.75. both lenses are placed at distance of 40 cm from each other. Due to the combination, the image of the object is formed at distance x = _____cm, from concave lens.



Ans. **120**

Sol. $\frac{1}{f}=(\mu_2-1)\times\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

For lens –1

$$\frac{1}{f_1}=0.75\times\left(-\frac{1}{30}\right) \quad \Rightarrow \quad f_1=-40 \text{ cm}$$

For lens –2

$$\frac{1}{f_2}=0.75\times\left(+\frac{1}{30}\right) \quad \Rightarrow \quad f_2=+40 \text{ cm}$$

Using lens formula

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

$u\to\infty$ $\quad\frac{1}{v}=\frac{1}{-40}$ $\quad\therefore$ v = –40 cm

This image will act as an object for 2nd lens.

Now, $u_2 = -80$ cm and $f_2 = +40$ cm, $v_2 = ?$

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\Rightarrow \quad \frac{1}{v_2} + \frac{1}{80} = \frac{1}{40}$$

$$\frac{1}{v_2} = \frac{1}{40} - \frac{1}{80} = \frac{1}{80}$$

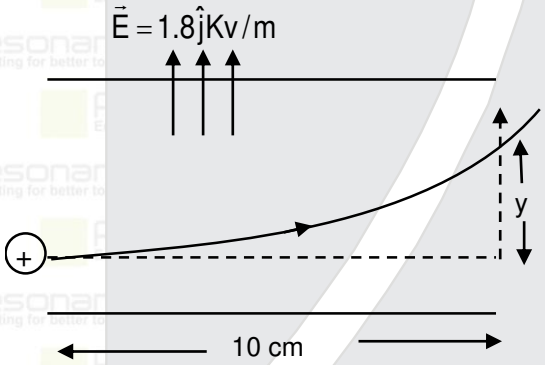
$$\therefore \quad v_2 = 80 \text{ cm}$$

Distance of final image from 1st lens is x = (40 + 80) = 120 cm

27. A stream of a positively charged particles $\frac{q}{m} = 2 \times 10^{11} \frac{C}{kg}$ and velocity $\vec{v}_\theta = 3\times10^7 \hat{i}$ m/s is deflected by an electric field $1.8\hat{j}$ k V/m. The electric field exists in a region of 10 cm along x direction. Due to the electric field, the deflection of the charge particles in the y direction is _____mm.

Ans. **2**

Sol.



$\vec{v}_x = \vec{v}_0 = 3\times10^7 \hat{i}$ m/s

$v_x = 3 \times 10^7$ m/s

$$\Rightarrow \quad t = \frac{x}{v_x}$$

$$t = \frac{10\times10^{-2}}{3\times10^7} s$$

$$t = \frac{1}{3\times10^8} s$$

Now in y–direction

$$y = u_y t + \frac{1}{2} a_y t^2$$

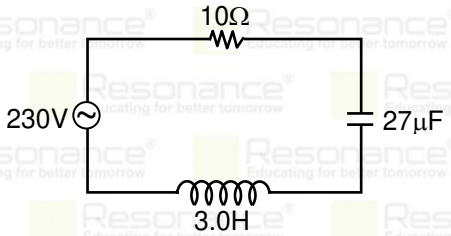
$$y = 0 + \frac{1}{2} \times \frac{qE}{m} \times t^2$$

$$y = \frac{1}{2} \times 2 \times 10^{11} \times 1.8 \times 10^3 \times \frac{1}{9\times10^{16}}$$

$y = 2 \times 10^{-3}$ m

$y = 2$mm

28. In the circuit shown in the figure, the ratio of the quality factor and the band width is _____s.



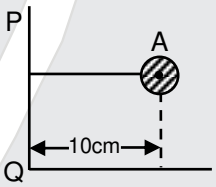
Ans. **10**

Sol. Band width = $\frac{R}{L} = \frac{10}{3}$

Quality factor = $\frac{\sqrt{L}}{R\sqrt{C}} = \frac{\sqrt{3}}{10\sqrt{27\times10^{-6}}}$

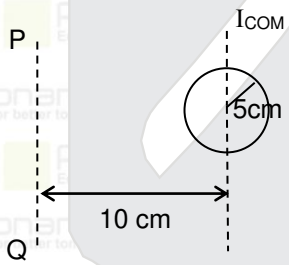
$$\frac{\text{quality factor}}{\text{Band width}} = \frac{\sqrt{3}\times3}{10\sqrt{27\times10^{-6}\times10}} = \frac{1}{10^{-1}} = 10$$

29. Solid sphere A is rotating about an axis PQ. If the radius of the sphere is 5 cm then its radius of gyration about PQ will be $\sqrt{x}$ cm. The value of x is _____.



Ans. **(110)**

Sol.



$I_{PQ} = I_{COM} + md^2$

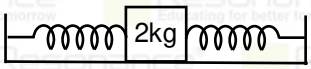
$I_{PQ} = \frac{2}{5} MR^2 + Md^2 = M\left[\frac{2}{5}\times25+10^2\right]$

$I_{PQ} = M[10 + 100] = 110\ M$

$MK^2 = 110\ M$

$k = \sqrt{110}$

30. A block of a mass 2 kg is attached with identical springs of spring constant 20 N/m. each. The block is placed on a frictionless surface and the ends of the spring are attached to right supports (see figure). When the mass is displaced from its equilibrium position, it executes a simple harmonic motion. The time period of oscillation is $\frac{\pi}{\sqrt{x}}$ in SI unit. The value of x is _____.



Ans. **5**

Sol. spring are is parallel.

$K_{net} = K_1 + K_2 = 40$

$\omega = \sqrt{\frac{K}{m}} = \sqrt{\frac{40}{2}} = \sqrt{20} \Rightarrow T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{20}} = \frac{\pi}{\sqrt{x}}$

$x = 5$

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