Pre-Board Examination : 2025-26
Sub : Physics

(The figures in the margin indicate full marks for the questions)

Time – 3 hours   Full marks-70

1. Answer following questions : 1x8=8

a If the force of attraction between two charges of equal magnitude is 9×10^5 N, separated by a distance of 1 m in vacuum , then magnitude of each charge will be

(a) 1 C (b) 0.1 C (c) 0.01 C (d) 0.001C

Ans

$$F = k\,\frac{|q_1q_2|}{r^2} \qquad \text{where } k = 9\times10^9\ \mathrm{N\,m^2/C^2}$$

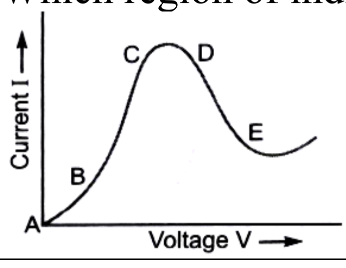
let $q_1 = q_2 = q$,

$$F = \frac{kq^2}{r^2} \qquad \text{given } F = 9\times10^5\ \mathrm{N} \text{ and } r = 1\ \mathrm{m}.$$

$$\Rightarrow q^2 = \frac{F\cdot r^2}{k} = \frac{(9\times10^5)(1)^2}{9\times10^9} = 10^{-4}$$

$$\Rightarrow q = \sqrt{10^{-4}} = 10^{-2}\ \mathrm{C}$$

b Graph showing the variation of current versus voltage for a material GaAs as shown in figure. Which region of indicate negative resistance



	(a)AB (b)BC (c)AC. (d)DE
Ans	Ans - (d) DE
c	Which material has negative susceptibility (a) Paramagnetic (b) Ferromagnetic (c) Diamagnetic (d) None of these
Ans	Ans - (c) Diamagnetic
d	If a change in current of 0.01 A in one coil produces a change in magnetic flux of 2 x 10^{-2} weber in another coil, then the mutual inductance between coils is (a) 0 (b) 1H (c) 2H (d) 3H
Ans	The mutual inductance M is defined by the ratio of the change in magnetic flux in one coil to the change in current in the other coil $\Delta\Phi_2 = M \cdot \Delta I_1 \Rightarrow M = \frac{\Delta\Phi_2}{\Delta I_1}$ $M = \frac{2 \times 10^{-2}}{0.01} = \frac{2 \times 10^{-2}}{10^{-2}} = 2\mathbf{H}$
e	Which of the following quantity remains constant in an ideal transformer? (a) Current (b) Voltage (c) Power (d) All of these
Ans	Ans- (c) Power
f	Energy of photon depends upon (a) Intensity (b)Saturation current (c)frequency (d)none
Ans	Ans- (c) frequency
g	The series of spectrum when electron jumps from n = 5 to n = 3 is

	(a) Lymen (b) Balmer (c) Paschen (d) Bracket
Ans	Ans- (c) Paschen
h	A In an insulator energy band gap is (a) E_g= 0eV (b) E_g> 3eV (c) E_g< 3eV (d) None
Ans	Ans- (b) E_g> 3eV
2	Give two similarities and disimilarities between Coulomb's law of electrostatics and Newton's law of Gravitation. 2
3	An aluminum wire of diameter 0.24 cm is connected in series to a copper wire of diameter 0.16 cm. The wires carry an electric current of 10 A. Find (a) current density of free electrons in the aluminum wire (b) drift velocity of electrons in the copper wire. (Number density of free electrons in Copper $=8.4\times10^{28}m^{-3}$) 2
Ans	**Diameter of aluminum (d_{Al}):** $0.24\,\text{cm} = 2.4 \times 10^{-3}\,\text{m}$ **Area of aluminum (A_{Al}):** $A_{Al} = \frac{\pi d^2}{4} = \frac{\pi \times (2.4 \times 10^{-3})^2}{4}$ $A_{Al} \approx 4.52 \times 10^{-6}\,\text{m}^2$ $A_{Al} \approx 4.52 \times 10^{-6}\,\text{m}^2$ **Current (I):** 10 A **Current Density (J_{Al}):** $J_{Al} = \frac{I}{A_{Al}} = \frac{10}{4.52 \times 10^{-6}} \approx \mathbf{2.21 \times 10^6\,A/m^2}$

	The drift velocity v_d is related to current I by the formula $I = nAev_d$, where n is the number density of free electrons **Diameter of copper (d_{Cu}):** $0.16\,\text{cm} = 1.6 \times 10^{-3}\,\text{m}$ **Area of copper (A_{Cu}):** $A_{Cu} = \frac{\pi \times (1.6 \times 10^{-3})^2}{4} \approx 2.01 \times 10^{-6}\,\text{m}^2$ **Number density (n_{Cu}):** $8.4 \times 10^{28}\,\text{m}^{-3}$ **Drift Velocity (v_d):** $v_d = \frac{I}{n_{Cu} \cdot A_{Cu} \cdot e}$ $v_d = \frac{10}{(8.4 \times 10^{28}) \times (2.01 \times 10^{-6}) \times (1.6 \times 10^{-19})}$ $v_d \approx \mathbf{3.70 \times 10^{-4}\,m/s}$
4	In an EM wave propagating along X-direction magnetic field oscillates at a frequency of 3×10^{10} Hz along Y direction and has an amplitude of 10^{-7}T. Find the expression for electric field . Find the wave velocity . 2
Ans	The amplitude of the electric field E_0 is related to the magnetic field amplitude B_0 $E_0 = cB_0 = (3 \times 10^8\,\text{m/s}) \times (10^{-7}\,\text{T}) = 30\,\text{V/m}$ given frequency $f = 3 \times 10^{10}\,\text{Hz}$ $\omega = 2\pi f = 2\pi(3 \times 10^{10}) = 6\pi \times 10^{10}\,\text{rad/s}$ $k = \frac{\omega}{c} = \frac{6\pi \times 10^{10}}{3 \times 10^8} = 200\pi\,\text{m}^{-1}$

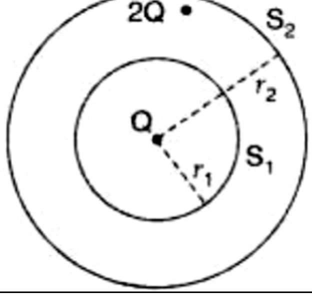
	The electric field oscillates along the Z-axis $E = E_0 \sin(\omega t - kx)$ $\Rightarrow \vec{E} = 30 \sin(6\pi \times 10^{10} t - 200\pi x)\hat{k}$ V/m
5	In a plane electromagnetic wave, the electric field oscillates sinusoidally at a frequency of 2.0×10^{10} Hz and amplitude 48 V m^{-1}. [c = 3×10^8 m/s] (a) What is the wavelength of the wave? (b) What is the amplitude of the oscillating magnetic field? . 2
Ans	The relationship between speed (c), frequency (f), and wavelength (λ) is given by the formula $c = f\lambda$ $\lambda = \frac{c}{f} \Rightarrow \lambda = \frac{3 \times 10^8}{2.0 \times 10^{10}}$ $= 1.5 \times 10^{-2}$ m Given $c = 3 \times 10^8$ m/s $f = 2.0 \times 10^{10}$ Hz $E_0 = 48$ V/m $c = 3 \times 10^8$ m/s $B_0 = \frac{E_0}{c} = \frac{48}{3 \times 10^8}$ $= 16 \times 10^{-8}$ T $\Rightarrow B_0 = 1.6 \times 10^{-7}$ T
	Or Show that the average energy density of the E field equals the average energy density of the B field. 2

Ans	Energy density in the electric field is $U_E = \frac{1}{2}\varepsilon_0 E^2$ Energy density in the magnetic field is $U_B = \frac{1}{2\mu_0}B^2$ We know E = Bc and $c = \frac{1}{\sqrt{\varepsilon_0\mu_0}}$ $U_E = \frac{1}{2}\varepsilon_0(cB)^2 = \frac{1}{2}\varepsilon_0\left(\frac{1}{\varepsilon_0\mu_0}\right)B^2 = \frac{B^2}{2\mu_0}$ now, $U_E = U_B$
6	How does the width of interference fringes in young's double slit experiment change when? (i)The distance between the slit and the screen is decreased (ii)The frequency of the source is increased. (iii) Seperation between the slits is doubled . 2
Ans	In Young's double slit experiment, the fringe width (β) is governed by the formula: $\beta = \frac{\lambda D}{d}$ where λ is the wavelength, D is the distance between the slits and the screen, and d is the separation between the slits. (i) **The distance between the slit and the screen is decreased:** $\beta \propto D$, reducing the distance D results in a narrower fringe width.

	(ii) **The frequency of the source is increased:** $\beta \propto \lambda$, frequency (f) and wavelength (λ) are inversely related to each other . Increasing the frequency decreases the wavelength, fringe width becomes smaller. (iii) **Separation between the slits is doubled:** $\beta \propto \frac{1}{d}$, Doubling the distance d between the slits causes the fringe width to be reduced by half.
7	(i) Light of wavelength 3500 Å is incident on two metals A and B. Which metal will yield more photoelectrons if their work functions are 5 eV and 2 eV respectively? (ii) Define threshold frequency. 2
Ans	The energy of a photon can be calculated using the formula: $E = \frac{hc}{\lambda}$ For wavelength λ_1 = 3500 Å =3500×10^{-10} m. $E = \frac{hc}{\lambda_1}$ $E = \frac{(6.626 \times 10^{-34}\,\mathrm{Js})(3 \times 10^{8}\,\mathrm{m/s})}{3.5 \times 10^{-7}\,\mathrm{m}}$ $E \approx 5.68 \times 10^{-19}\,\mathrm{J}$ $E \approx \frac{5.68 \times 10^{-19}}{1.6 \times 10^{-19}} \approx 3.55\,\mathrm{eV}$

	For metal A: $E = 3.55\,\mathrm{eV} > \phi_A = 3.2\,\mathrm{eV}$ (Photoelectrons will be emitted) For metal B: $E = 3.55\,\mathrm{eV} > \phi_B = 1.9\,\mathrm{eV}$ (Photoelectrons will also be emitted)
8	Name the constituent radiation of electromagnetic spectrum which is used for (i) aircraft navigation (ii) studying the crystal structure. Write the frequency range for each . 2
Ans	(i) Aircraft navigation: Microwaves are used for radar systems in aircraft navigation. ¿ Frequency Range: Approximately 10^{10} Hz to 10^{12} Hz. (i) Studying crystal structure: X-rays are used for studying crystal structure, a technique known as X-ray diffraction. Frequency Range: Approximately 10^{16} Hz to 10^{20} Hz. Microwaves are ideal for navigation due to their short wavelengths, which allow for precise detection in radar systems. X-rays are suitable for analyzing atomic arrangements in crystals because their wavelengths are comparable to the interatomic spacing in materials.
9	(i) State two important features of Einstein's photoelectric equation. (ii) Radiation of frequency 10^{15} Hz is incident on

	two photosensitive surfaces P and Q. There is no photoemission from surface P. Photoemission occurs from surface Q but photoelectrons have zero kinetic energy. Explain these observations & find the value of work function for surface Q. 2
Ans	Emission of photoelectrons takes place from surface Q but not from P If implies that work function for surface P is more than that of Q. $$\phi_P > \phi_Q$$ Also K.E of emitted photoelectrons is zero $\Rightarrow$ incident energy = work function $\Rightarrow h\nu = \phi$ $\Rightarrow \phi = 6.634 \times 10^{-34} \times 10^{15} = 6.634 \times 10^{-19}$ J $= \dfrac{6.634\times10^{-19}}{1.6\times10^{-19}} eV = 4$ eV
10	Using the Rydberg formula, calculate the Wavelengths of the first four spectral lines in the Lyman series of the hydrogen spectrum. 2
Ans	$$\lambda = \frac{91.2 \text{ nm}}{\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]}$$ (i) 1st line of Lyman series : $n_1 = 1$ and $n_2 = 2$ $$\lambda_{2\to1} = \frac{91.2 \text{ nm}}{\left[\frac{1}{1^2} - \frac{1}{2^2}\right]} = \frac{91.2 \text{ nm}}{\frac{3}{4}} = \frac{4}{3} \times 91.2\text{nm} = 121.6 \text{ nm}$$ (ii) 2nd line of Lyman series : $n_1 = 1$ and $n_2 = 3$ $$\lambda_{3\to1} = \frac{91.2 \text{ nm}}{\left[\frac{1}{1^2} - \frac{1}{3^2}\right]} = \frac{91.2 \text{ nm}}{\frac{8}{9}} = \frac{9}{8} \times 91.2\text{nm} = 106.6 \text{ nm}$$ (iii) 3rd line of Lyman series : $n_1 = 1$ and $n_2 = 4$

	$\lambda_{4\to1} = \dfrac{91.2\text{ nm}}{\left[\frac{1}{1^2}-\frac{1}{4^2}\right]} = \dfrac{91.2\text{ nm}}{\frac{15}{16}} = \dfrac{16}{15} \times 91.2\text{nm} = 97.28\text{ nm}$ (iv) 4th line of Lyman series : $n_1 = 1$ and $n_2 = 5$ $\lambda_{5\to1} = \dfrac{91.2\text{ nm}}{\left[\frac{1}{1^2}-\frac{1}{5^2}\right]} = \dfrac{91.2\text{ nm}}{\frac{24}{25}} = \dfrac{25}{24} \times 91.2\text{nm} = 95\text{ nm}$
11	How much energy should be given to uranium to eject one proton from its nucleus? **Given:** ${}^{238}_{92}U = 238.05079\ amu$ ${}^{237}_{91}Pa = 237.05121\ amu$ ${}^{1}_{1}H = 1.00783\ amu$ $1\ amu = 931.5\ MeV$ 2 Or Distinguish between isotopes and isobars. Give one example for each of the species. 2
Ans	**Reaction:** ${}^{238}_{92}\text{U} + \text{Energy} \to {}^{237}_{91}\text{Pa} + {}^{1}_{1}\text{H}.$ $\Delta m = m_U - (m_{Pa} + m_H)$ $= 238.05079 - (237.05121 + 1.00783)$ $= 238.05079 - 238.05904 = -0.00825\text{ u}$ $E = \Delta m \times 931\text{ MeV} = -0.00825 \times 931$ $E = -7.68075\text{ MeV}$ So energy to be given to the Uranium to saperate one proton from its nucleus is 7.68075 MeV
12	

	A sphere S_1 of radius r_1 encloses a net charge Q. If there is another concentric sphere S_2 of radius r_2 ($r_2 > r_1$) enclosing charge 2Q. **(i)** Find the ratio of the electric flux through S_1 and S_2. **(ii)** How will the electric flux through sphere S_1 change if a medium of dielectric constant K is introduced in the space inside S_2 in place of air? 3
Ans	Flux through S_1, $\phi_1 = \frac{Q}{\varepsilon_0}$ Flux through S_2, $\phi_2 = \frac{Q+2Q}{\varepsilon_0} = \frac{3Q}{\varepsilon_0}$ Ratio of flux = 1 : 3 No change in the flux through S_1 with dielectric medium inside the sphere S_2.
	Or (i) Apply Gauss's law to derive the expression for electric field intensity due to a thin sheet of charge . (ii) Draw the graph between the electric intensity due to a thin sheet of charge and the distance of the point of observation from the thin sheet of charge . 2+1=3
13	(i) The electric potential V at any point in space is given $V = 20x^3$ volt, where x is in meter. Calculate the electric intensity at point P (1, 0, 2). (ii) Find equivalent capacitance between A and B in the combination given below: each capacitor is

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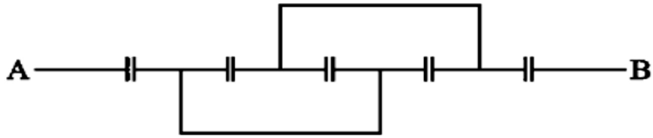
of 2 μF.



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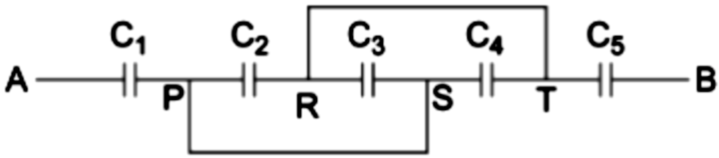
<tr><td>Ans</td><td>

(i) $E = -\frac{dV}{dx} = -\frac{d(20x^3)}{dx} = -60\,x^2$

At P(1 , 0 , 2) m

$E = -60(1)^2 = -60\ \frac{V}{m}$

Direction of E is along - X axis



(ii) Capacitors C_2, C_3 and C_4 are in parallel

$C_{234} = C_2 + C_3 + C_4 = 2\mu F + 2\mu F + 2\mu F$

$\therefore C_{234} = 6\mu F$

Capacitors C_1, C_{234} and C_5 are in series,

$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_{234}} + \frac{1}{C_5} = \frac{1}{2} + \frac{1}{6} + \frac{1}{2} = \frac{7}{6}\mu F$

$C_{eq} = \frac{6}{7}\mu F$

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Or

Prove that electric field at the surface of a charged conductor is $\vec{E} = \frac{\sigma}{\varepsilon_0}\hat{n}$,where σ is the surface charge density and $\hat{\boldsymbol{n}}$ is a unit vector normal to the surface in the outward direction. 3

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<tr><td>**14**</td><td>(i) Prove that drift velocity of the free electrons in a</td></tr>
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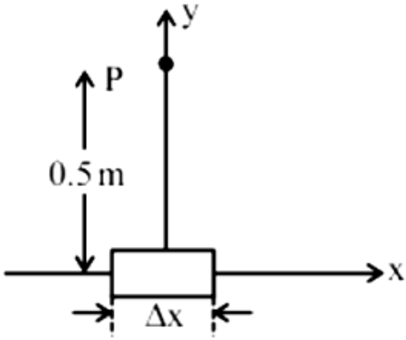
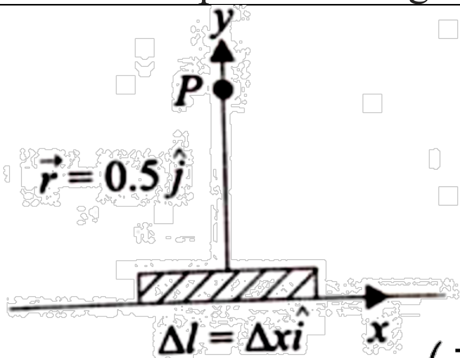
	conductor is time dependent velocity . (ii) How does drift velocity of free electrons in conductor is related to temperature ? 3 Or (i) A silver wire has a resistance of 2.1 Ω at 27.5 °C, and a resistance of 2.7 Ω at 100 °C. Determine the temperature coefficient of resistivity of silver. (ii) Show the variation of resistivity of (a)Nichrome with temperature (b) Silicon with temperature. 2+1=3
Ans	(i) Temperature, $T_1 = 27.5°C$ Resistance of the silver wire at T_1, $R_1 = 2.1\ \Omega$ Temperature, $T_2 = 100°C$ Resistance of the silver wire at T_2, $R_2 = 2.7\ \Omega$ Temperature coefficient of silver = α It is related with temperature and resistance as $\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)} = \frac{2.7 - 2.1}{2.1(100 - 27.5)} = \frac{0.6}{152.25}$ $= 0.0039°C^{-1}$ Therefore, the temperature coefficient of silver is $0.0039°C^{-1}$
15	(i) An element Δx is placed at the origin and carries a large current of 10 A . What is the magnetic field on the y-axis at a distance of 0.5 m. Δx = 1 cm.



(ii) Under what condition a moving charge will follow a helical path in a magnetic field.Explain. 3

Ans



By Biot-Savart law, $\overrightarrow{dB} = \frac{\mu_0 i}{4\pi}\frac{\left(\vec{d\ell} \times \vec{r}\right)}{r^3}$ (Tesla)

Since element is very small,

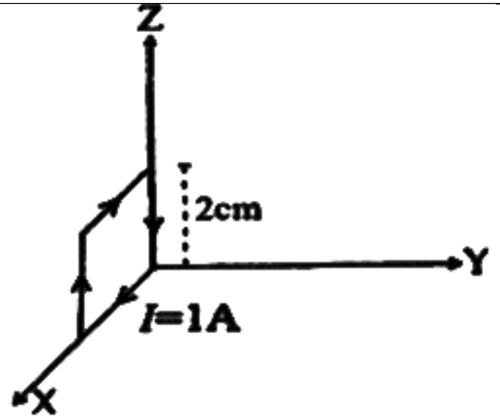
Given: $\vec{d\ell} = \frac{1}{100}\hat{i}\ m, \vec{r} = \frac{1}{2}\hat{j}\ m,\ i = 10\text{ A},\ \theta = 90°$

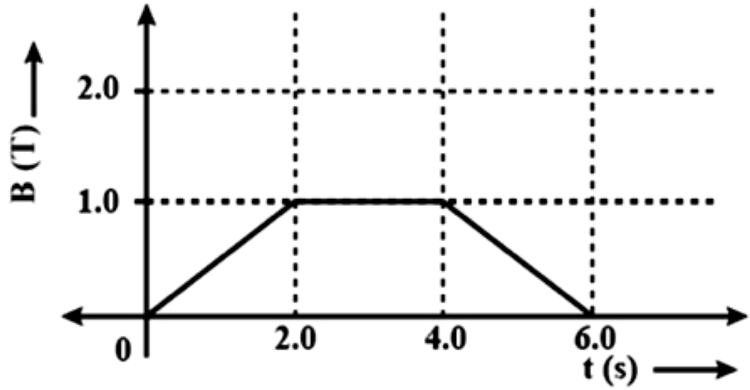
$$\overrightarrow{dB} = 10^{-7} \times 10 \times \frac{\left(\frac{1}{100}\hat{i} \times \frac{1}{2}\hat{j}\right)}{\left(\frac{1}{2}\right)^3} = 10^{-7} \times 10 \times \frac{8}{200}\hat{k}$$

$$= 4 \times 10^{-8}\text{ T}\left(+\hat{k}\right)$$

Or

Find the magnitude and direction of the torque acting on the square loop of side 2 cm as shown in the diagram where B=1.5T along positive Z axis.

	 3
Ans	$\lvert\tau\rvert = m \times B = mB\sin\theta\left(\hat{j} \times \widehat{k}\right)$ $= NIAB\sin\theta\left(\hat{j} \times \widehat{k}\right)$ $= 4 \times 10^{-4} \times 1.5\left(\hat{j} \times \widehat{k}\right)$ $= 6 \times 10^{-4} N - m\left(\hat{i}\right)$ Here, $N = 1, I = 1A$ $A = 4 \times 10^{-4} m^2$ $B = 1.5T$ $\sin\theta = \sin 90^\circ = 1$ Also, τ is directed along positive x-direction.
16	(i) What is electromagnetic induction (ii) The magnetic field through a circular loop of wire, 12cm in radius and 8.5Ω resistance, changes with time as shown in the figure. The magnetic field is perpendicular to the plane of the loop. Calculate the current induced in the loop .

	 (iii) Draw the graph between current and time . 3 Or Derive an expression for the energy stored in a solenoid . Also find its energy density . 2+ 1 = 3
Ans	(ii) Area of the circular loop = $\pi r^2 = 3.14 \times (0.12)^2\ m^2$ $= 4.5 \times 10^{-2}\ m^2$ $E = -\frac{d\phi}{dt} = -\frac{d}{dt}(BA) = -A\frac{dB}{dt} = -A\frac{B_2 - B_1}{t_2 - t_1}$ For $0 < t < 2s$ $E_1 = -4.5 \times 10^{-2} \times \left\{\frac{1-0}{2-0}\right\} = -2.25 \times 10^{-2}V$ $\therefore I_1 = \frac{E_1}{R} = \frac{-2.25 \times 10^{-2}}{8.5}A = -2.6 \times 10^{-3}A$ $= -2.6\ mA$

$$E_2 = -4.5 \times 10^{-2} \times \left\{\frac{1-1}{4-2}\right\} = 0$$

$$\therefore I_2 = \frac{E_2}{R} = 0$$

For 4s < t < 6s,

$$I_3 = -\frac{4.5 \times 10^{-2}}{8.5} \times \left\{\frac{0-1}{6-4}\right\} A = 2.6\ mA$$

	0 < t < 2s	2 < t < 4s	4 < t < 6s
E(V)	- 0.023	0	+ 0.023
I(mA)	- 2.6	0	+ 2.6

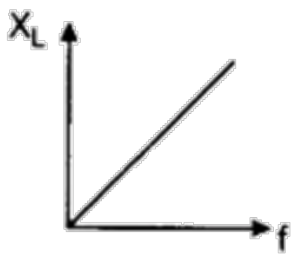
17 (i)An ac voltage of emf $e = E_0 \sin \omega t$ is applied across an inductor of self inductance L, find an expression for the AC flowing in the circuit. Draw the phasor diagram to show the phase relationship between current and voltage.

(ii)What is inductive reactance ? Draw its variation with ω . 1½+1+½=3

Ans (ii) Inductive reactance is the opposition offered by an inductor to the flow of alternating current trough it .

Inductive reactance (X_L) = 2πfL

$\therefore \quad X_L \propto f$



Or

	Find the expression for power in LCR circuit . 3
18	(i) State the principle on which the working of an optical fiber is based. (ii) What are the necessary conditions for this phenomenon to occur? (iii) Write down some uses of it . 1+1+1= 3 Or (i) A beam of light consisting of two wavelength 800 nm and 600 nm is used to obtain the interference pattern in young's double slit experiment on a screen placed 1.4 m away. If the separation between two slits in 0.28 mm. Calculate the least distance from the central bright maximum, where the bright fringes of two wavelengths coincide. (ii) Find the position of the 5th dark fringe from the central bright fringe due 800 nm. 1½+1½=3
Ans	Given: − $\lambda_1 = 800\text{ nm} = 800 \times 10^{-9}$ m $\lambda_2 = 600\text{ nm} = 600 \times 10^{-9}$ m D = 1.4 m $d = 0.28\text{ mm} = 0.28 \times 10^{-3}$ m Let n_1^{th} maximum corresponds to λ_1 coincides with n_2^{th} maximum corresponds to λ_2. Then, $n_1 \frac{\lambda_1 D}{d} = n_2 \frac{(\lambda_2) D}{d}$ or , $\frac{n_1}{n^2} = \frac{\lambda^2}{\lambda^1} = \frac{600}{800} = \frac{3}{4}$ The minimum integral value of n_1 is 3 and of n_2 is 4. Therefore, the minimum value of *y* is,

	$y_{\min} = n_1 \frac{\lambda_1 D}{d} = \frac{3 \times 800 \times 10^{-9} \times 1.4}{(0.28) \times 10^{-3}}$ $y_{\min} = 12mm$
19	**(i)** What intrinsic semiconductor ? Draw its energy band diagram at ordinary temperature . 1+1=2 **(ii)** In a p-n junction, width of depletion region is 300 nm and electric field of 7×10^5 V/m exists in it. Find the height of potential barrier. 1
Ans	Width (d): 300 nm $= 300 \times 10^{-9}$ m Electric Field (E): 7×10^5 V/m The relationship between the electric field (E), the width of the depletion region (d), and the potential barrier height (V_B) is given $V_B = E \times d = (7 \times 10^5 \text{ V/m}) \times (300 \times 10^{-9} \text{ m})$ $= 2100 \times 10^{-4}$ V $V_B = 0.21$ V
	Or (i) Give the differences among metal , insulator semiconductor and in terms of conductivity. 1 (ii) Carbon, silicon and germanium have four valence electrons each. These are characterized by valence and conduction bands separated by energy band gap respectively equal to $(E_g)_C$, $(E_g)_{Si}$ and $(E_g)_{Ge}$. Arrange them in descending order . 1 (iii) What reverse saturation current . 1

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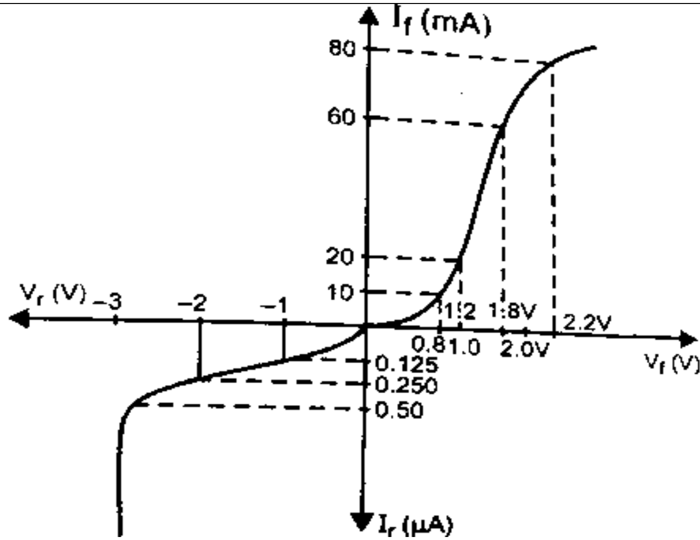


(i) Calculate the resistance of the diode during forward and reverse biasing.

(ii) Find the knee voltage and Zener voltage in the graph. . 2+½+½=3

Or

Explain the working of full wave rectifier. 3

Ans

(i)

(a) the forward bias diode resistance is given by $r_f = \frac{\Delta V}{\Delta I}$,

where ΔV *and* ΔI are the small changes in voltage and current near the desired voltages.

$$r_f(at + 2V) = \frac{(2.2 - 1.8)V}{(80 - 60)mA} = \frac{0.4\ V}{20\ \times 10^{-3}\ A} = 20\ \Omega$$

$$r_f(at + 1V) = \frac{(1.2 - 0.8)V}{(20 - 10)mA} = \frac{0.4\ V}{10\ \times 10^{-3}\ A} = 40\ \Omega$$

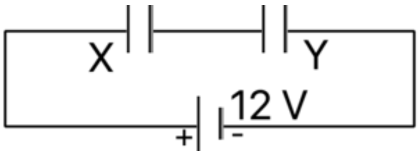
(b) in the reverse bias characteristic, the non-linearity in the V-I curve is small. The slopes of V-I curve at -1 V and -2 V are nearly equal.

$$r_r(at-2V) = \frac{-2\ V}{-0.25\ \mu A} = 8\ \times 10^6\ \Omega$$

Also, $r_r(at-1V) = 8\ \times 10^6\ \Omega$

(ii)Knee voltage = 0.8Vand Zener voltage = - 3V

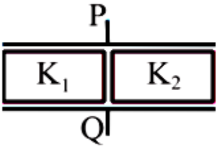
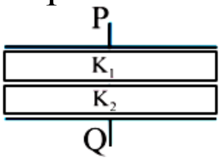
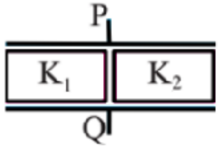
21 Fig. shows two parallel plate capacitors X and Y having same area of plates and same separation between them : X has air while Y has dielectric of constant 4 as medium between plates.

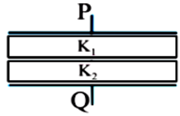


(a) calculate capacitance of each capacitor, if equivalent capacitance of combination is 4μF
(b) calculate potential difference between plate X and Y
(c)Find the ratio of electrostatic energy stored in X & Y.

Ans The capacitance of a parallel plate capacitor is $C = \frac{\epsilon_0 A}{d}$ for air and $C = \frac{K\epsilon_0 A}{d}$ for a dielectric. Since both have the same area A and separation d :
Let the capacitance of X (air) be C_X= C
The capacitance of Y(dielectric K=4) is C_Y=4C

	.For a series combination, the equivalent capacitance C_{eq} is: $$\frac{1}{C_{eq}} = \frac{1}{C_X} + \frac{1}{C_Y}$$ $$4\ \mu\text{ F} = \frac{C_X \cdot C_Y}{C_X + C_Y} = \frac{C \cdot 4C}{C + 4C} = \frac{4C^2}{5C} = \frac{4}{5}C$$ Solving for C: $C = 5\ \mu\text{ F}$ Thus: $C_X = \mathbf{5}\ \mu\text{ F}$ $C_Y = 4 \times 5 = \mathbf{20}\ \mu\text{ F}$ In a series circuit, the charge Q on each capacitor is the same. Using $Q = C_{eq}V_{total}$ let's assume a standard total voltage $V = 15$ V Charge $Q = 4\ \mu\text{ F} \times 15\text{ V} = 60\ \mu\text{ C}$. Potential difference across X : $V_X = \frac{Q}{C_X} = \frac{60}{5} = \mathbf{12}$ V Potential difference across Y : $V_Y = \frac{Q}{C_Y} = \frac{60}{20} = \mathbf{3}$ V. The electrostatic energy stored in a capacitor is $U = \frac{1}{2}CV^2$ or $U = \frac{Q^2}{2C}$. Since Q is constant in series: $$\frac{U_X}{U_Y} = \frac{\frac{Q^2}{2C_X}}{\frac{Q^2}{2C_Y}} = \frac{C_Y}{C_X} = \frac{20\ \mu\text{ F}}{5\ \mu\text{ F}} = \mathbf{4}$$
	Or You are given an air filled parallel plate capacitor.

	Two slabs of dielectric constants K_1 and K_2 having been filled in between the two plates of the capacitor as shown in Fig. What will be the capacitance of the capacitor of initial area was A distance between plates d?  
Ans	Capacitance without a dielectric medium in between the plates $C_0 = \frac{\varepsilon_0 A}{d}$ With dielectric medium within plates- $C_1 = K_1 \frac{\varepsilon_0 A/2}{d}$ $C_2 = K_2 \frac{\varepsilon_0 A/2}{d}$  Since C_1 and C_2 in parallel $C_p = C_1 + C_2 = K_1 \frac{\varepsilon_0 A}{2d} + K_2 \frac{\varepsilon_0 A}{2d} = \frac{\varepsilon_0 A}{d}\left[\frac{K_1}{2} + \frac{K_2}{2}\right]$ $\Rightarrow C_p = C_0\left[\frac{K_1 + K_2}{2}\right]$

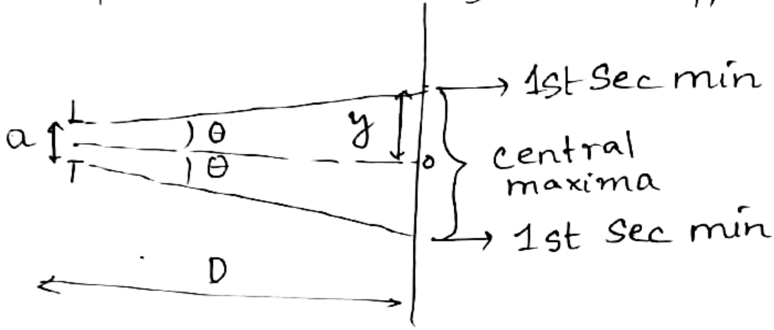
	Capacitance without a dielectric medium in between the plates $C_0 = \frac{\varepsilon_0 A}{d}$ With dielectric medium within plates- $C_1 = K_1 \frac{\varepsilon_0 A}{d/2}$ $\quad C_2 = K_2 \frac{\varepsilon_0 A}{d/2}$  Since C_1 and C_2 in series $\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2}$ $\Rightarrow \frac{1}{C_S} = \frac{1}{K_1 \frac{\varepsilon_0 A}{d/2}} + \frac{1}{K_2 \frac{\varepsilon_0 A}{d/2}} = \frac{d}{2 \cdot K_1 \varepsilon_0 A} + \frac{d}{2 \cdot K_2 \varepsilon_0 A}$ $\Rightarrow \frac{1}{C_S} = \frac{d}{2 \varepsilon_0 A}\left[\frac{1}{K_1} + \frac{1}{K_2}\right]$ $\Rightarrow C_S = \frac{2 \cdot \varepsilon_0 A}{d}\left[\frac{K_1 K_2}{K_1 + K_2}\right] = 2C_0\left[\frac{K_1 K_2}{K_1 + K_2}\right]$ $\Rightarrow C_S = C_0\left[\frac{2 K_1 K_2}{K_1 + K_2}\right]$
22	(i) Draw a labelled ray diagram of astronomical telescope . Write the formula for magnifying power . 3 **(ii)** An optical instrument uses eye-lens of power 20 D and the objective lens of power 50 D. Name the optical instrument and calculate its magnifying power if it forms the final image at infinity. 2

Ans	The optical instrument has $f_0 = \frac{1}{50D} = 0.02 \text{ m} = 2 \text{ cm}$ $f_e = \frac{1}{20D} = 0.05 \text{ m} = 5 \text{ cm}$ (a) The instrument must be a compound microscope as $f_0 < f_e$ (b) Since the final image is formed at infinity, the image produced by the objective should lie on the focal plane of the eye piece. So , tube length , $L = \|f_o\| + \|f_e\|$ $= 2 + 5 = 7 \text{ cm}$ Its magnifying power is given by the tube formula , when final image is at infinity . $M = \frac{L}{f_o} \times \frac{D}{f_e}$ [Taking D = 25 cm] $\Rightarrow M = \frac{7}{2} \times \frac{25}{5} = 17.5$
	Or **(i)** Explain the formation secondary maxima due to diffraction of light through a single slit . **2½** **(ii)** Graphical Representation of intensity pattern for diffraction . **1** **(iii)** In the experiment on diffraction due to a single slit, show that the angular width of the central maximum is twice that of the first order secondary maximum. **1½**

Ans

WIDTH OF CENTRAL MAXIMA = TWICE OF β IN YDSE Date - 18/2/12

Let a be the width of the slit in single slit diffraction



For 1st sec min

$$a\sin\theta = 1\lambda \quad (n=1)$$

$$\Rightarrow \sin\theta = \frac{\lambda}{a} \quad --- (I)$$

If θ is very very small

$$\theta = \frac{\lambda}{a} \quad --- (II)$$

From fig $\tan\theta = \frac{y}{D}$

$$\Rightarrow \theta = \frac{y}{D} \quad -(III) \quad \left[\text{as } \theta \text{ is very small}\right]$$

From (II) & (III) $\Rightarrow \frac{\lambda}{a} = \frac{y}{D}$

$$\Rightarrow y = \frac{\lambda D}{a} \quad -(IV)$$

So total width of central maxima

$$\omega_{CM} = 2y = \frac{2\lambda D}{a} \quad --- (V)$$

Again fringewidth in YDSE,

$$\beta = \frac{\lambda D}{a} \quad --- (VI)$$

So $\boxed{\omega_{CM} = 2\beta}$ —(VII) of YDSE

width of central maxima is 2β (twice the fringe width

23	**(i)** Show that the energy of an electron in the orbit of the hydrogen atom varies inversely as n^2, where n is the principal quantum number of the atom. **(ii)** The ground state energy of hydrogen atom is **-13.6 eV**. what is the kinetic energy and the potential energy of an electron in the 2nd excited state . 3+2 = 5
Ans	The total energy E_n of an electron in the n^{th} orbit is given by the formula: $E_n = \frac{E_1}{n^2}$ Given the ground state energy $E_1 = -13.6\text{ eV}$ Applying thesFor the 2nd excited state and $n = 3$: $E_3 = \frac{-13.6}{3^2} = \frac{-13.6}{9} \approx -1.51\text{ eV}$ Based on Bohr's model, the relationships between total energy(E), kinetic energy (KE),and potential energy (PE) are: **Kinetic Energy:**$KE = -E = -(-1.51\text{ eV}) = 1.51\text{eV}$ **Potential Energy:** $PE = 2E = 2 \times (-1.51\text{ eV})$ $= -3.02\text{ eV}$ •
	Or **(i)** What 1 amu ? Give its energy equivalent . **(ii)** Convert 5 mg of matter into MeV . (iii) Give the difference between nuclear fission and nuclear fision. 1½+1½ + 2 =5
Ans	(ii)

	Given mass: $m = 5\text{ mg} = 5 \times 10^{-6}\text{ kg}$ Use the formula $E = mc^2$, where $c \approx 3 \times 10^8\text{ m/s}$ $E = (5 \times 10^{-6}\text{ kg}) \times (299,792,458\text{ m/s})^2$ $E \approx 4.4938 \times 10^{11}\text{ J}$ $E_{\text{MeV}} = \dfrac{4.4938 \times 10^{11}\text{ J}}{1.60218 \times 10^{-13}\text{ J/MeV}}$ $E_{\text{MeV}} \approx 2.8048 \times 10^{24}\text{ MeV}$