Series BVM/2 **SET-2**

PHYSICS

Paper & Solution

Code No. : 55/2/2

Time : 3 Hrs. **Max. Marks : 70**

***General Instruction* :**

(i) *All questions are compulsory. There are **27** questions in all.*

(ii) *This question paper has **four** sections : Section A, Section B, Section C, Section D.*

(iii) *Section A contain **five** questions of **one** mark each. Section B contains **seven** questions of **two** marks each, Section C contains **twelve** questions of **three** marks each, Section D contains **three** questions of **five** marks each.*

(iv) *There is no overall choice. However, an internal choice(s) has been provided in **two** question of **one** marks, **two** question of **two** marks, **four** questions of **three** marks weightage. You have to attempt only **one** of the choices in such questions.*

(v) *You may use the following values of physical constants wherever necessary :*

$c = 3 \times 10^8$ m/s

$h = 6.63 \times 10^{-34}$ Js

$e = 1.6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T mA^{-1}

$\varepsilon_0 = 8.854 \times 10^{-12}$ C^{2}N^{-1}m^{-2}

$$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$$

$m_e = 9.1 \times 10^{-31}$ kg

Mass of Neutrons = 1.675×10^{-27} kg

Mass of proton = 1.673×10^{-27} kg

Avogadro's number = 6.023×10^{23} per gram mole

Boltzmann constant = 1.38×10^{-23} JK^{-1}

SECTION A

Q.1 Write the relation for the force acting on a charged particle q moving with velocity $\vec{v}$ in the presence of a magnetic field $\vec{B}$. **[1]**

Sol. $F = q(\vec{v} \times \vec{B})$

Q.2 The magnetic susceptibility of magnesium at 300 K is $1{\cdot}2 \times 10^5$. At what temperature will its magnetic susceptibility become $1{\cdot}44 \times 10^5$? **[1]**

OR

The magnetic susceptibility χ of a given material is – 0·5. Identify the magnetic material.

Sol. $\chi \propto \frac{1}{T}$

$$\frac{\chi_1}{\chi_2} = \frac{T_2}{T_1} \Rightarrow \frac{1{\cdot}2\times10}{1{\cdot}44\times10} = \frac{T_2}{300}$$

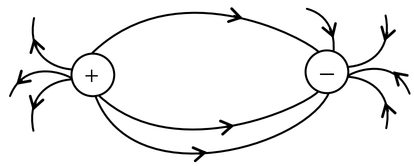
$$T_2 = \frac{3000}{1{\cdot}2} = \frac{500}{2} = 250 \text{ K}$$

OR

Diamagnetic

Q.3 Draw the pattern of electric field lines due to an electric dipole. **[1]**

Sol.



Q.4 Which part of the electromagnetic spectrum is used in RADAR? Give its frequency range. **[1]**

OR

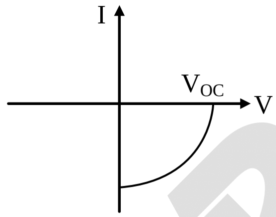
How are electromagnetic waves produced by accelerating charges?

Sol. 3KHz – 300 GHz

OR

By accelerating charge particle produce changing E & B field.

Q.5 Identify the semiconductor diode whose I-V characteristics are as shown. **[1]**



Sol. Solar Cell

SECTION B

Q.6 A photon and a proton have the same de-Broglie wavelength λ. Prove that the energy of the photon is $(2m\lambda c/h)$ times the kinetic energy of the proton. **[2]**

Sol. $E = h\nu \rightarrow$ Photon

$$\lambda = \frac{h}{P}$$

$$P = \frac{h}{\lambda}$$

$$mV = \frac{h}{\lambda}$$

$$V = \frac{h}{\lambda m}$$

$$E = \frac{hC}{\lambda}$$

Kinetic energy of proton

$$k = \frac{1}{2}mV^2$$

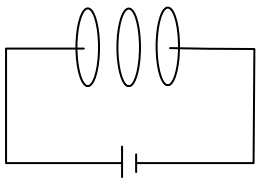
$$k = \frac{1}{2}m\left(\frac{h}{\lambda m}\right)^2$$

$$k = \frac{1}{2}\,\frac{h^2}{\lambda^2 \cdot m}$$

$$\frac{E}{k} = \frac{\frac{hC}{\lambda}}{\frac{h^2}{2\lambda^2 m}} = \frac{2mC\lambda}{h}$$

Q.7 How is the equation for Ampere's circuital law modified in the presence of displacement current ? Explain. **[2]**

Sol.



$I_d = f_0 \dfrac{d\phi}{dt}$

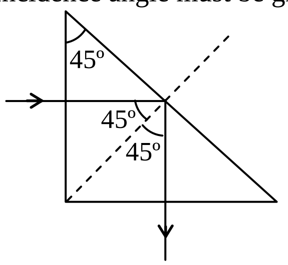
Ampere – Maxwell equation

$\oint \vec{B}.d\vec{\ell} = \mu_0 \Sigma I_d + \mu_0 \Sigma I_1$

Q.8 Under what conditions does the phenomenon of total internal reflection take place ? Draw a ray diagram showing how a ray of light deviates by 90º after passing through a right-angled isosceles prism. **[2]**

Sol. (a) Light must pass from denser to rarer medium

(b) Incidence angle must be greater then critical angle



Q.9 A photon emitted during the de-excitation of electron from a state n to the first excited state in a hydrogen atom, irradiates a metallic cathode of work function 2 eV, in a photo cell, with a stopping potential of 0·55 V. Obtain the value of the quantum number of the state n. **[2]**

OR

A hydrogen atom in the ground state is excited by an electron beam of 12·5 eV energy. Find out the maximum number of lines emitted by the atom from its excited state.

Sol. $13.6\ Z^2 \left\{\dfrac{1}{2^2} - \dfrac{1}{n^2}\right\} eV = eV_0 + \phi$

$13.6\ (1)^2 \left\{\dfrac{1}{4} - \dfrac{1}{n^2}\right\} eV = 0.55 eV + 2\ eV$

$13.6 \left\{\dfrac{1}{4} - \dfrac{1}{n^2}\right\} = 2.55$

$\dfrac{1}{4} - \dfrac{1}{n^2} = \dfrac{2.55}{13.6}$

$\Rightarrow \dfrac{1}{n^2} = \dfrac{1}{4} - \dfrac{2.55}{13.6}$

$\dfrac{1}{n^2} = \dfrac{13.6 - 10.20}{4 \times 13.6} = \dfrac{1}{n^2} = \dfrac{34}{4 \times 13.6}$

$\Rightarrow \boxed{n = 4}$

OR

This beam can excite atom upto n = 3

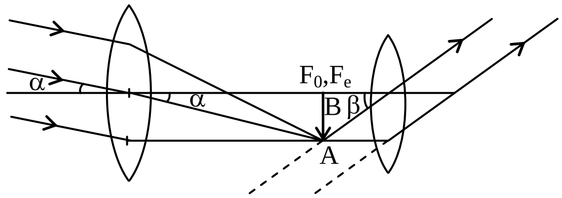
Thus maximum no. of lines = $\dfrac{3(3-1)}{2} = 3$

Q.10 Draw the ray diagram of an astronomical telescope showing image formation in the normal adjustment position. Write the expression for its magnifying power. **[2]**

OR

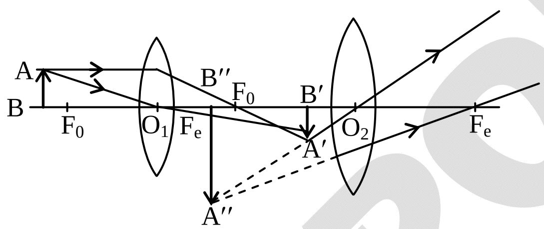
Draw a labelled ray diagram to show image formation by a compound microscope and write the expression for its resolving power.

Sol.



$$m = \frac{\beta}{\alpha} = \frac{-AB/F_e}{AB/f_0} = -\frac{f_0}{f_e}$$

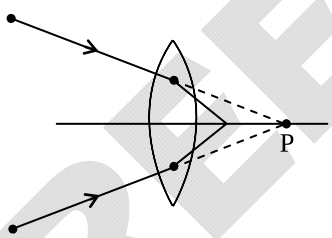
OR



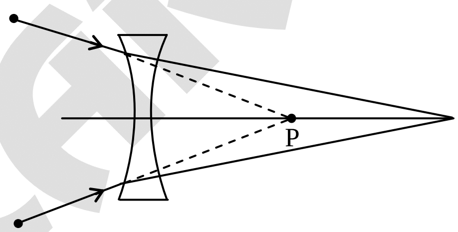
$$\text{Resolving power} = \frac{2\mu \sin\beta}{1.22\lambda}$$

Q.11 A beam of light converges at a point P. Draw ray diagrams to show where the beam will converge if (i) a convex lens, and (ii) a concave lens is kept in the path of the beam. **[2]**

Sol. (i)



(ii)



Q.12 Write the relation between the height of a TV antenna and the maximum range up to which signals transmitted by the antenna can be received. How is this expression modified in the case of line of sight communication by space waves? In which range of frequencies, is this mode of communication used? **[2]**

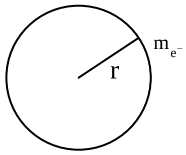
Sol. $d = \sqrt{2RH_T} + \sqrt{2RH_T}$

Frequency range should be greater than 40 MHz.

SECTION C

Q.13 Prove that the magnetic moment of the electron revolving around a nucleus in an orbit of radius r with orbital speed v is equal to evr/2. Hence using Bohr's postulate of quantization of angular momentum, deduce the expression for the magnetic moment of hydrogen atom in the ground state. **[3]**

Sol.



$I = \frac{e}{T}$ $\qquad V = \frac{2\pi r}{T}$

$I = \frac{eV}{2\pi r}$

$\mu = IA$

$\mu = \frac{eV}{2\pi r} \cdot \pi r^2 = \frac{eVr}{2}$

$\boxed{\mu = \frac{eVr}{2}}$

$\mu = \frac{eVr \cdot m_e}{2 \cdot m_e}$ $\qquad \left\{ mVr = \frac{nh}{2\pi} \right\}$

$\mu = \frac{enh}{2m \times 2\pi}$

n = 1 ground state

$\mu = \frac{eh}{4\pi m}$

Q.14 (a) How is the stability of hydrogen atom in Bohr model explained by de-Broglie's hypothesis ?

(b) A hydrogen atom initially in the ground state absorbs a photon which excites it to n = 4 level. When it gets de-excited, find the maximum number of lines which are emitted by the atom. Identify the series to which these lines belong. Which of them has the shortest wavelength ? **[3]**

Sol. (a) $n\lambda = 2\pi r$ ....(i)

$\lambda = \frac{h}{P}$ ....(ii) (de-Broglie wavelength)

$\frac{n.h}{P} = 2\pi r$

$\frac{n.h}{mvr} = 2\pi$

$mvr = \frac{n.h}{2\pi}$

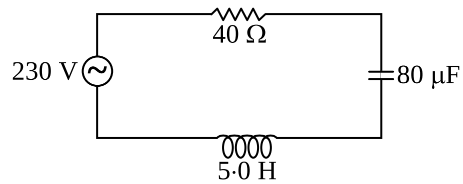
(b) $\frac{n(n-1)}{2} = \frac{4(3)}{2} = 6$

Series belong to Lyman, Balmer, Paschen

Q.15 A capacitor (C) and resistor (R) are connected in series with an ac source of voltage of frequency 50 Hz. The potential difference across C and R are respectively 120 V, 90 V, and the current in the circuit is 3 A. Calculate (i) the impedance of the circuit (ii) the value of the inductance, which when connected in series with C and R will make the power factor of the circuit unity. **[3]**

OR

The figure shows a series LCR circuit connected to a variable frequency 230 V source.



(a) Determine the source frequency which drives the circuit in resonance.
(b) Calculate the impedance of the circuit and amplitude of current at resonance.
(c) Show that potential drop across LC combination is zero at resonating frequency.

Sol. (a) $X_L = X_C$

$$5\cdot\omega = \frac{1}{W\cdot 80\times10^{-6}}$$

$$\omega^2 = \frac{1}{400\times10^{-6}}$$

$$\omega^2 = \frac{1}{4\times10^{-4}}$$

$$\omega = \frac{1}{2\times10^{-2}} = 50 \text{ rad/sec}$$

(b) $Z = 40\Omega,\ I_0 = \dfrac{230\sqrt{2}}{40} = \dfrac{23\sqrt{2}}{4}$

(c) $X_L = 50 \times 5 = 250\ \Omega$

$$X_C = \frac{1}{50\times80\times10^{-6}} = \frac{1}{4\times10^{-3}} = 250\ \Omega$$

current is same in series that why voltage drop will same.

Q.16 What is the reason to operate photodiodes in reverse bias ?
A p-n photodiode is fabricated from a semiconductor with a band gap of range of 2.5 to 2.8 eV. Calculate the range of wavelengths of the radiation which can be detected by the photodiode. **[3]**

Sol. Reverse connection of photo diode due to we use reverse current when signal detecting on it.

$$\lambda = \frac{12400\ \text{Å}}{0.3}$$

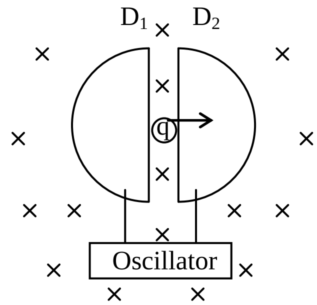
$\lambda = 41400$ Å

Q.17 Draw a labelled diagram of cyclotron. Explain its working principle. Show that cyclotron frequency is independent of the speed and radius of the orbit. **[3]**

OR

(a) Derive, with the help of a diagram, the expression for the magnetic field inside a very long solenoid having n turns per unit length carrying a current I.
(b) How is a toroid different from a solenoid?

Sol.



Principle : the frequency of charge particle moving in magnetic field is independent of its speed.

$$qvB = \frac{mv^2}{r}$$

$$r = \frac{mv}{qB}$$

$$v = r\omega$$

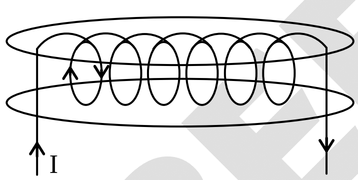
$$\omega = \frac{v}{r} = \frac{qB}{m}$$

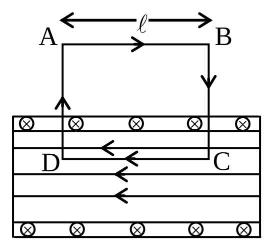
$$2\pi f = \frac{qB}{m}$$

$$\boxed{f = \frac{qB}{2\pi m}}$$

OR

(a)





From Ampere's law

$$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I_{en}$$

$$\int_{AB} \vec{B} \cdot d\vec{\ell} + \int_{BC} \vec{B} \cdot d\vec{\ell} + \int_{CD} \vec{B} \cdot d\vec{\ell} + \int_{DA} \vec{B} \cdot d\vec{\ell} = \mu_0 I_{en}$$

$$0 + 0 + \int B\ell \cos 0 + 0 = \mu_0(N)I$$

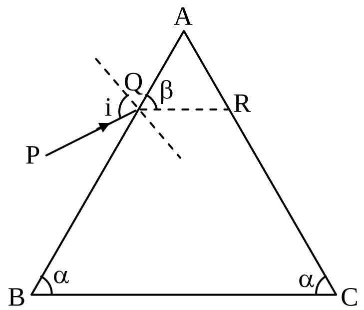
$$= B(\ell) = \mu_0 NI$$

$$B = \mu_0 \left(\frac{N}{\ell}\right) I$$

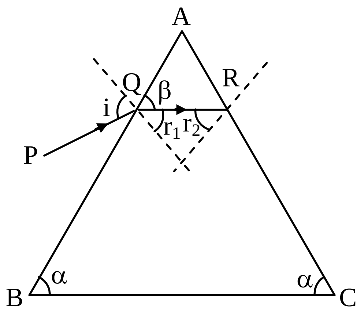
$$\Rightarrow B = \mu_0 nI \text{ here } n = \frac{N}{\ell}$$

(b) solenoid has N-S poles where as toroid doesn't have separate poles

Q.18 A ray of light incident on the face AB of an isosceles triangular prism makes an angle of incidence (i) and deviates by angle β as shown in the figure. Show that in the position of minimum deviation. $\angle\beta = \angle\alpha$. Also find out the condition when the refracted ray QR suffers total internal reflection. **[3]**



Sol.



For minimum deviation QR || BC

$$\frac{\sin(i)}{\sin(r_1)} = \frac{\mu}{1} \text{ at face AB}$$

$$\frac{\sin(r_2)}{\sin(e)} = \frac{1}{\mu} \text{ at face AC}$$

$\sin(i) = \sin(e)$

Here $r_1 = 90^\circ - \beta$ $\quad (r_1 = r_2)$

so α is equal to β

for TIR $\dfrac{\sin(r_2)}{\sin 90^\circ} = \dfrac{1}{\mu}$

$$\sin(90^\circ - \beta) = \frac{1}{\mu}$$

$$\cos\beta = \frac{1}{\mu}$$

Q.19 Two large charged plane sheets of charge densities σ and -2σ C/m^2 are arranged vertically with a separation of d between them. Deduce expressions for the electric field at points **[3]**

(i) to the left of the first sheet

(ii) to the right of the second sheet, and

(iii) between the two sheets.

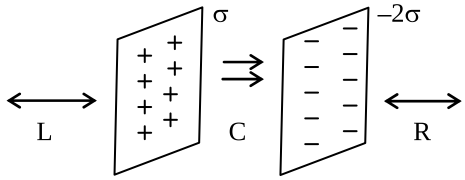
OR

A spherical conducting shell of inner radius r_1 and outer radius r_2 has a charge Q.

(a) A charge q is placed at the centre of the shell. Find out the surface charge density on the inner and outer surfaces of the shell.

(b) Is the electric field inside a cavity (with no charge) zero; independent of the fact whether the shell is spherical or not? Explain.

Sol.



Side

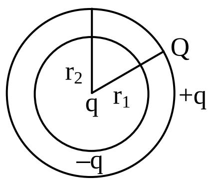
(L) $E_{Net} = \frac{\sigma}{2 \in_0} - \frac{2\sigma}{2 \in_0} = -\frac{\sigma}{\in_0}$ (toward R)

(C) $E_{Net} = \frac{\sigma}{2 \in_0} - \frac{\sigma}{\in_0} = \frac{\sigma + 2\sigma}{2 \in_0} = \frac{3\sigma}{2 \in_0}$ (toward R)

(R) $E_{Net} = \frac{\sigma}{2 \in_0} - \frac{\sigma}{\in_0} = \frac{\sigma - 2\sigma}{2 \in_0} = -\frac{\sigma}{\in_0}$ (toward L)

OR

(a)



Outer surface $(\sigma_1) = \frac{Q+q}{4\pi r_2^2}$

inner surface $(\sigma_2) = \frac{-q}{4\pi r_1^2}$

(b) inside the cavity without any charge net electric field is always zero according to gauss law.

Q.20 A signal of low frequency f_m is to be transmitted using a carrier wave of frequency f_c. Derive the expression for the amplitude modulated wave and deduce expressions for the lower and upper sidebands produced. Hence, obtain the expression for modulation index. **[3]**

Sol. $m(t) = A_m \sin(\omega_m t)$

$C(t) = A_C \sin(\omega_c t)$

AM Modulation Wave

$C(t) = [A_c + A_m \sin(\omega_m t)] \sin(\omega_c t)$

$C(t) = A_c\left[1 + \frac{Am}{Ac}\sin(\omega_m t)\right]\sin(\omega_c t)$

$= A_c[1 + \mu \sin(\omega_c t)]\sin(\omega_c t)$

$= A_c \cdot \sin(\omega_c t) + A_c \cdot \mu \sin(\omega_m t)\sin(\omega_c t)$

$= A_c \sin(\omega_c t) + \frac{A_c \mu}{2}[cs(\omega_c - \omega_m)t - cs(\omega_c + \omega_m)]$

$= A_c \sin(\omega_c t) + \frac{A_c \mu}{2}\cos(\omega_c - \omega_m)t - \frac{A_c \mu}{2}\cos(\omega_c + \omega_m)$

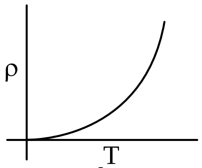
Here $\mu = \frac{A_m}{A_c}$

(Modulating index)

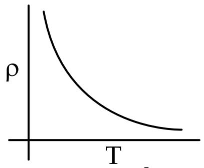
Q.21 Show, on a plot, variation of resistivity of (i) a conductor, and (ii) a typical semiconductor as a function of temperature.

Using the expression for the resistivity in terms of number density and relaxation time between the collisions, explain how resistivity in the case of a conductor increases while it decreases in a semiconductor, with the rise of temperature. **[3]**

Sol.



Conductors



Semi-Conductors

As we know

$$j = \frac{I}{A}$$

$$j = \frac{neV_dA}{A}$$

$$j = ne\left(\frac{eE}{m}\tau\right)$$

$$\sigma E = \frac{ne^2E}{m}\tau$$

$$\sigma = \frac{ne^2\tau}{m}$$

$$\rho = \frac{m}{ne^2\tau}$$

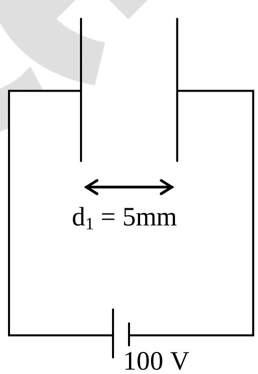
$$\rho \propto \frac{1}{\tau} \ \& \ T \propto \frac{1}{\tau}$$

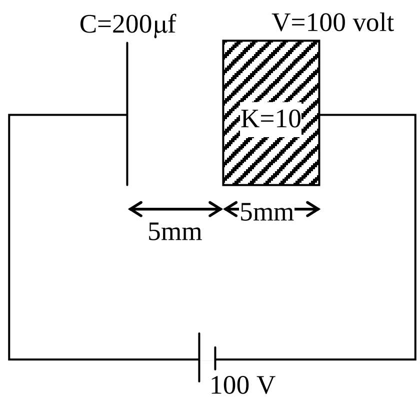
$$\rho \propto T$$

in conductors the collision of e^- will be increases & in semi-conductors the new e^- holes pair creates & conductivity increases.

Q.22 A 100 μF parallel plate capacitor having plate separation of 4 mm is charged by a 200 V dc source. It remains connected to the source. Using an insulated handle, the distance between the plates is doubled and a dielectric slab of thickness 4 mm and dielectric constant 5 is introduced between the plates. Explain with reason, how the (i) capacitance, (ii) electric field between the plates and (iii) energy density of the capacitor get affected ? Justify your answer in each case. **[3]**

Sol.





(i) $C_0 = \frac{\epsilon_0 A}{d} = \frac{\epsilon_0 A}{5}$ ...(i)

$C_1 = \frac{\epsilon_0 A}{5} = c_0$

$C_2 = \frac{10 \epsilon_0 A}{5} = 10C_0$

$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{10C_0^2}{11C_0}$

$C_{eq} = \frac{10}{11} C_0$ ...(ii)

From (ii)/(i)

$\boxed{\frac{C_{eq}}{C_0} = \frac{\epsilon_0 A/d}{\frac{10}{11}\frac{\epsilon_0 A}{d}} = \frac{11}{10}}$ $\frac{C_{net}}{C_0} = \frac{11}{10}$

(ii) $E_0 = \frac{\sigma'}{\epsilon_0}$ & $E_d = \frac{\sigma'}{\epsilon_0 \cdot K}$ Or $V = E_0 \cdot d + \frac{E_0 \cdot d}{K}$

$E = \frac{V}{2 \cdot d} = \left(E_0 \cdot d + \frac{E_0 \cdot d}{K}\right) \times \frac{1}{2d}$

$E = \frac{1}{2}\left(E_0 + \frac{E_0}{K}\right)$

$E = \frac{E_0}{2}\left(1 + \frac{1}{K}\right)$

(iii) Energy $E = \frac{1}{2} C_{Net} V^2$

$E = \frac{1}{2}\frac{10}{11}\frac{\epsilon_0 A}{d} \cdot (100)^2$

$E = \frac{1}{2} \times \frac{10}{11} \times 200 \times 10^{-6} \times 10^4$

Energy $= \frac{10}{11}$ Joule

SECTION D

Q.23 Why is it difficult to detect the presence of an anti-neutrino during β-decay? Define the term decay constant of a radioactive nucleus and derive the expression for its mean life in terms of the decay constant. **[3]**

OR

(a) State two distinguishing features of nuclear force.

(b) Draw a plot showing the variation of potential energy of a pair of nucleons as a function of their separation. Mark the regions on the graph where the force is (i) attractive, and (ii) repulsive.

Sol. Since neutrino and antinutrino are very small particles which rarely intracts with the matter thus its very difficult to detect them.

Decay constant $\Rightarrow$ It is the reciprocal of that time in which N_0 of active nuclei reduces to 37% of initial active nuclei.

Mean life $\Rightarrow \because\ \tau = \dfrac{\int (dN)t}{\int dN}$ .....(i)

$\because \left|-\dfrac{dN}{dt}\right| = \lambda N \Rightarrow dN = \lambda N\ dt$

Thus from (i)

$$\tau = \frac{\int \lambda N t dt}{N_0} = \frac{\int \lambda N_0 t e^{-\lambda t} dt}{N_0} \quad \{\because\ N = N_0 e^{-\lambda t}\}$$

$$\tau = \lambda \int_0^\infty t e^{-\lambda t} dt$$

$$= \lambda\left(\frac{1}{\lambda^2}\right)$$

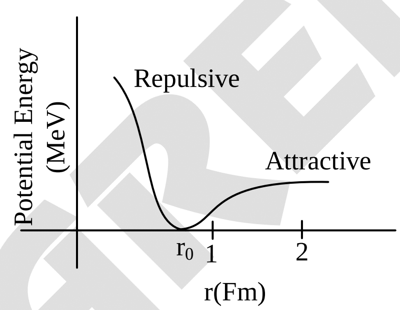
$$\tau = \frac{1}{\lambda}$$

OR

(a) (i) Short range force

(ii) Very strong force

(b)

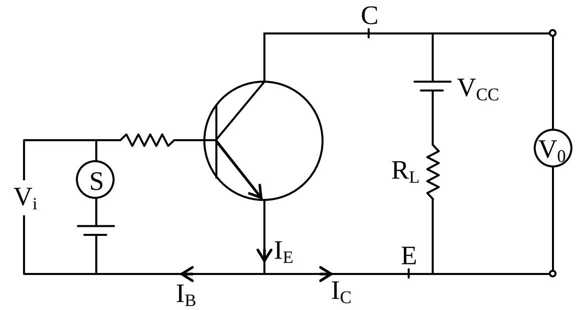


(i) if $r > r_0$ attractive

(ii) if $r < r_0$ repulsive

Q.24 Prove that in a common-emitter amplifier, the output and input differ in phase by 180º.
In a transistor, the change of base current by 30 mA produces change of 0.02 V in the base-emitter voltage and a change of 4 μA in the collector current. Calculate the current amplification factor and the load resistance used, if the voltage gain of the amplifier is 400. **[3]**

Sol.



$V_{CE} = V_{CC} - I_C R_L$

When i_B increase as in first half cycle the i_C will also increase as well as the V_{CE} = –ve this negative sign show the cycle is at phase 180º.

Here $I_B = 30\ \mu A$

$V_i = 0.02$ V

$I_C = 4$ mA

$$\beta = \frac{I_C}{I_B} = \frac{4\times10^{-3}}{30\times10^{-6}} = \frac{4000}{30} = \frac{400}{3}$$

$$R_L = \frac{V_0}{I_C}$$

$$\frac{V_0}{V_i} = 400$$

$V_0 = 400 \times V_i = 400 \times 0.02 = 8V$

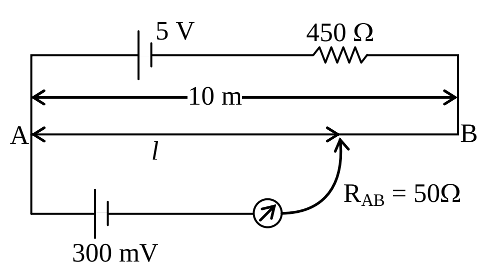
$$R_L = \frac{8}{4\times10^{-3}} = \frac{8000}{4} = 2000\Omega$$

SECTION D

Q.25 (a) Describe briefly, with the help of a circuit diagram, the method of measuring the internal resistance of a cell.

(b) Give reason why a potentiometer is preferred over a voltmeter for the measurement of emf of a cell.

(c) In the potentiometer circuit given below, calculate the balancing length *l*. Give reason, whether the circuit will work, if the driver cell of emf 5V is replaced with a cell of 2 V, keeping all other factors constant. **[5]**



OR

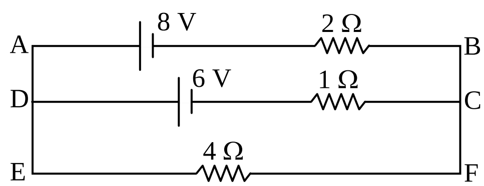
(a) State the working principle of a meter bridge used to measure an unknown resistance.

(b) Give reason

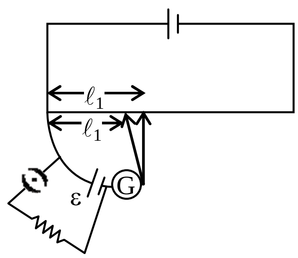
(i) why the connections between the resistors in a metre bridge are made of thick copper strips.

(ii) why is it generally preferred to obtain the balance length near the mid-point of the bridge wire.

(c) Calculate the potential difference across the 4 Ω resistor in the given electrical circuit, using Kirchhoff's rules.



Sol. (a)



$\varepsilon = V_S \cdot \ell_1$

$V = V_S \cdot \ell_2$

$$\frac{\varepsilon}{V} = \frac{\ell_1}{\ell_2}$$

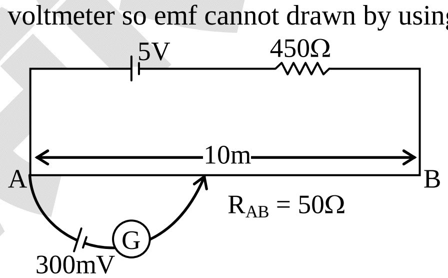
$$\frac{Ir + IR}{IR} = \frac{\ell_1}{\ell_2}$$

$$\frac{r}{R} = \frac{\ell_1}{\ell_2} - 1$$

$$r = R\left(\frac{\ell_1}{\ell_2} - 1\right)$$

(b) Potentiometer work on no current flow method but voltmeter work on current flow through voltmeter so emf cannot drawn by using voltmeter.

(c)



$R_{Net} = 500\Omega$

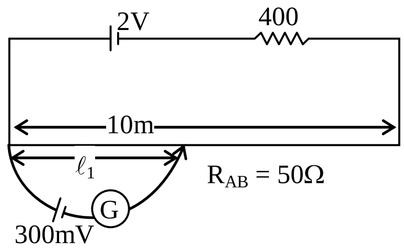
$$i = \frac{5}{500} = \frac{1}{100} \text{ A}$$

$$V_{AB} = \frac{1}{100} \times 50 = \frac{1}{2}$$

$\varepsilon = V_S \cdot \ell$

$$\ell = \frac{\varepsilon}{V_S}$$

$$\ell = \frac{300\times10^{-3}}{\frac{1}{20}} = 6\text{m}$$



$$i = \frac{2}{500} = \frac{1}{250}\text{ A}$$

$$V_{AB} = \frac{1}{200} \times 50 = \frac{1}{5}\text{ Volt}$$

$$V_S = \frac{\frac{1}{5}}{10} = \frac{1}{50}\text{ V/m}$$

$$\varepsilon = V_S \cdot \ell_1$$

$$\ell_1 = \frac{300\times10^{-3}}{\frac{1}{50}}$$

$$\ell_1 = 15000 \times 10^{-3}$$

$$\ell_1 = 15\text{m}$$

So, the circuit will not work due to balancing length is greater than original length of wire.

OR

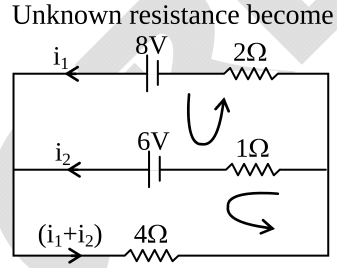
(a) meter bridge work on the principle of wheat stone bridge

(b) (i) because thick wire has low resistance which can not alter the value of unknown resistance

(ii) If balance length become at mid point so that R = S

$$\frac{R}{\ell} = \frac{S}{(100-\ell)}$$

Unknown resistance become equal to standard resistance.



(c)

$-2i_1 + 8 - 6 + i_2 = 0$

$2i_1 - i_2 = 2$ …(i)

$-i_2 + 6 - 4i_1 - 4i_2 = 0$

$-4i_1 - 5i_2 = -6$

$4i_1 + 5i_2 = 6$ …(ii)

$$\begin{array}{r} 2 \times (2i_1 - i_2 = 2) \\ -\quad +\quad - \\ \hline 7i_2 = 2 \\ \hline \end{array}$$

$$i_2 = \frac{2}{7}$$

$$2i_1 - \frac{2}{7} = 2$$

$$2i_1 = 2 + \frac{2}{7}$$

$$2i_1 = \frac{16}{7}$$

$$\boxed{i_2 = \frac{8}{7}}$$

Voltage at 4Ω will be

$V = (i_1 + i_2)\cdot 4$

$$= \left(\frac{10}{7}\right) \times 4 = \frac{40}{7} \text{ Volt}$$

Q.26 (a) Derive an expression for the induced emf developed when a coil of N turns, and area of cross-section A, is rotated at a constant angular speed ω in a uniform magnetic field B.

(b) A wheel with 100 metallic spokes each 0·5 m long is rotated with a speed of 120 rev/min in a plane normal to the horizontal component of the Earth's magnetic field. If the resultant magnetic field at that place is 4×10^{-4} T and the angle of dip at the place is 30º, find the emf induced between the axle and the rim of the wheel. **[5]**

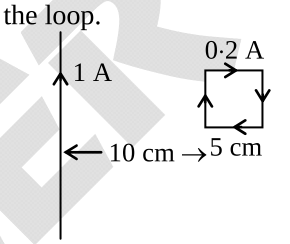
OR

(a) Derive the expression for the magnetic energy stored in an inductor when a current I develops in it. Hence, obtain the expression for the magnetic energy density.

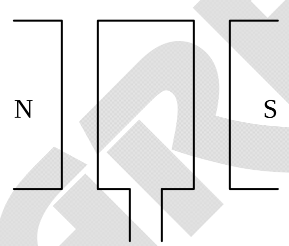
(b) A square loop of sides 5 cm carrying a current of 0·2 A in the clockwise direction is placed at a distance of 10 cm from an infinitely long wire carrying a current of 1 A as shown. Calculate

(i) the resultant magnetic force, and

(ii) the torque, if any, acting on the loop.



Sol. (a)



$N\phi = N\cdot BA\cdot\cos(\omega t)$

$$\frac{Nd\phi}{dt} = N\cdot BA(-\sin(\omega t)\cdot\omega$$

$$\because \ \varepsilon = -N\frac{d\phi}{dt}$$

$-\varepsilon = -NBA\omega \sin(\omega t)$

$\varepsilon = NBA\omega\sin(\omega t)$

$\boxed{\varepsilon = \varepsilon_0\sin(\omega t)}$

Induce emf in coil

(b) induced emf $= \frac{1}{2}B\ell^2\omega$

$= \frac{1}{2} \times 4 \times 10^{-4} \times \cos 30^\circ \times 0.5 \times 4\pi$

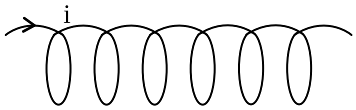
$= \sqrt{3} \times 10^{-4} \times \frac{1}{2} \times 4\pi$

$= 2\pi\sqrt{3} \times 10^{-4}$ V

The number of spokes is immaterial because the emf's across the spokes are in parallel.

OR

(a)



$\varepsilon = \frac{Ldi}{dt}$

Power $= \varepsilon \cdot i$

$\frac{dW}{dt} = \frac{Ldi}{dt} \cdot i \Rightarrow \int dW = \int Lidi$

$W = \frac{1}{2}Li^2$

$L = \mu_0\left(\frac{N}{\ell}\right)^2 A\ell$

$L = \frac{\mu_0 N^2 A}{\ell}$

$B = \mu_0 ni$

$B = \mu_0 \frac{N}{\ell} i$

$i = \frac{B\ell}{\mu_0 N}$

$W = \frac{1}{2}\left(\frac{\mu_0 N^2 A}{\ell}\right)\left(\frac{B\ell}{\mu_0 N}\right)^2$

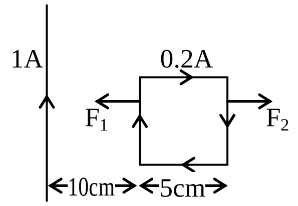
$= \frac{\mu_0 N^2 A}{2\ell} \times \frac{B^2\ell^2}{\mu_0^2 N^2}$

$W = \frac{1}{2}\frac{B^2 \ell A}{\mu_0}$

Energy density $= \frac{W}{A \cdot \ell}$

$= \frac{1}{2}\frac{B^2 \ell A}{\mu_0} \times \frac{1}{A\ell}$

$= \frac{B^2}{2\mu_0}$

(b) 

$$F_1 = \frac{\mu_0(1)}{2\pi(10^{-1})} \times 0.2 \times 5 \times 10^{-2}$$

$$= \frac{24\pi \times 10^{-7} \times 0.2 \times 5 \times 10^{-2}}{2\pi \times 10^{-1}}$$

$$F_1 = 2 \times 10^{-8}\ \text{N}$$

$$F_2 = \frac{\mu_0(1)}{2\pi(15 \times 10^{-2})} \times 0.2 \times 5 \times 10^{-2}$$

$$= \frac{4\pi \times 10^{-7} \times 10^{-2}}{2\pi \times 15 \times 10^{-2}}$$

$$= \frac{2}{15} \times 10^{-7}$$

$$F_{Net} = F_1 - F_2$$

$$= 2 \times 10^{-8} - \frac{2}{15} \times 10^{-7}$$

$$= 2 \times 10^{-8} - \frac{4}{3} \times 10^{-8}$$

$$= 10^{-8}\left(2 - \frac{4}{3}\right)$$

$$F_{Net} = 10^{-8}\left(\frac{2}{3}\right)\text{N}$$

No torque will be act on coil.

Q.27 Explain, with the help of a diagram, how plane polarized light can be produced by scattering of light from the Sun.

Two polaroids P_1 and P_2 are placed with their pass axes perpendicular to each other. Unpolarised light of intensity I is incident on P_1. A third Polaroid P_3 is kept between P_1 and P_2 such that its pass axis makes an angle of 45º with that of P_1. Calculate the intensity of light transmitted through P_1, P_2 and P_3. **[5]**

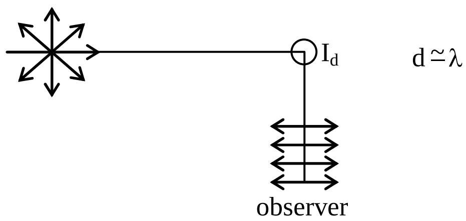
OR

(a) Why cannot the phenomenon of interference be observed by illuminating two pin holes with two sodium lamps?

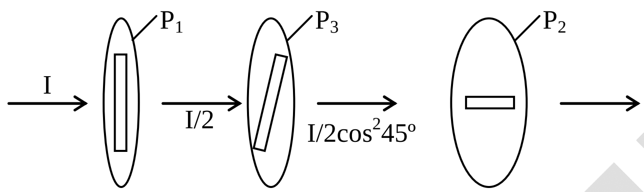
(b) Two monochromatic waves having displacements $y_1 = a \cos \omega t$ and $y_2 = a \cos (\omega t + \phi)$ from two coherent sources interfere to produce an interference pattern. Derive the expression for the resultant intensity and obtain the conditions for constructive and destructive interference.

(c) Two wavelengths of sodium light of 590 nm and 596 nm are used in turn to study the diffraction taking place at a single slit of aperture 2×10^{-6} m. If the distance between the slit and the screen is 1·5 m, calculate the separation between the positions of the second maxima of diffraction pattern obtained in the two cases.

Sol.



if object size around wavelength of light get scattered & at 90º placed observer get the polarised light due to all vibration of light used for oscillating molecules except perpendicular



Intensity of light after passing $P_1 = \frac{I}{2}$

Intensity of light after passing $P_2 = \frac{I}{2} \times \left(\frac{1}{\sqrt{2}}\right)^2 = \frac{I}{4}$

Intensity of light after passing $P_3 = \frac{I}{4}\cos^2 45^\circ$

$= I \times \left(\frac{1}{\sqrt{2}}\right)^2 = \frac{I}{8}$

OR

(a) Two lamps not a coherent source that why their phase difference not constant with time.

(b) $y = y_1 + y_2$

$y = a\cos(\omega t) + a\cos(\omega t + \phi)$

$y = a\cdot\cos(\omega t) + a[\cos(\omega t)\cdot\cos\phi - \sin(\omega t)\sin\phi]$

$y = a\cdot\cos(\omega t) + a\cdot\cos(\omega t)\cdot\cos\phi - a\cdot\sin(\omega t)\sin\phi$

$y = (a + a\cdot\cos\phi)\cdot\cos(\omega t) - a\cdot\sin\phi\cdot\sin(\omega t)$

$a + a\cos\phi = R\cdot\sin\theta$ ...(i)

$-a\sin\phi = R\cdot\cos\theta$ ...(ii)

$y = R\cdot\sin\theta\cdot\cos(\omega t) + R\cdot\cos\theta\cdot\sin(\omega t)$

$y = R\sin(\omega t + \theta)$

$(i)^2 + (ii)^2$

$(a + a\cdot\cos\phi)^2 + (-a\sin\phi)^2 = R^2$

$a^2 + a^2\cdot\cos^2\phi + 2a^2\cos\phi + a^2\sin^2\phi = R^2$

$a^2 + a^2 + 2a^2\cdot\cos\phi = R^2$

$R^2 = 2a^2 + 2a^2\cdot\cos\phi$

$R^2 = 2a^2(1 + \cos\phi)$

$R^2 = 2a^2(1 + 2\cos^2\frac{\phi}{2} - 1)$

$R^2 = 4a^2 \cdot \cos^2\frac{\phi}{2}$

$I_{Net} = 4 \cdot I_0 \cdot \cos^2\frac{\phi}{2}$

constructive $\phi = 0, 2\pi, 4\pi \ldots.$

$I_{Net} = 4I_0 \cdot \cos^2(0°)$

$\boxed{I_{Net} = 4I_0}$

Destructive $\phi = \pi, 3\pi, 5\pi$

$I_{Net} = 4I_0\cos^2\left(\frac{\pi}{2}\right)$

$\boxed{I_{Net} = 0}$

(c) $y_1 = \frac{D}{a} \cdot \frac{5\lambda_1}{2}$

$y_2 = \frac{D}{a} \cdot \frac{5\lambda_2}{2}$

$\Delta y = \frac{5D}{2a}[\lambda_2 - \lambda_1]$

$\Delta y = \frac{2\times10^{-6}\times5}{2} \; \frac{1.5\times5}{2\times2\times10^{-6}} \; [6 - 10^{-9}]$

$\Delta y = \frac{7.5}{4} \times 6 \times \; 10^{-3}$

$\Delta y = 7.5 \times 1.5 \times 10^{-3} = 11.5 \times 10^{-3}$