PHYSICS

SET I

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

General Instructions

(a) All questions are compulsory.

(b) There are 30 questions in total. Questions 1 to 8 carry one mark each, questions 9 to 18 carry two marks each, questions 19 to 27 carry three marks each and questions 28 to 30 carry five marks each.

(c) There is no overall choice. However, an internal choice has been provided in one question of two marks, one question of three marks and all three questions of five marks each. You have to attempt only one of the given choices in such questions.

(d) Use of calculators is not permitted.

(e) You may use the following physical constants wherever necessary :

$c = 3 \times 10^{8} ms^{-1}$

$h = 6.6 \times 10^{-34} Js$

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

$m_0 = 4p \times 10^{-7}$ TmA^{-1}

Boltzmann constant $k = 1.38 \times 10^{23}$ JK^{-1}

Avogadro's number NA = 6.023×10^{23}/mole

Mass of neutron $m_n = 1.6 \times 10^{-27}$ kg

SECTION A

1. Two identical charged particles moving with same speed enter a region of uniform magnetic field. If one of these enters normal to the field direction and the other enters along a direction at 30^0 with the field, what would be the ratio of their angular frequencies?

2. Why does a metallic piece become very hot when it is surrounded by a coil carrying high frequency alternating current?

3. How is a sample of an n-type semiconductor electrically neutral though it has an excess of negative charge carriers?

4. Name the characteristics of electromagnetic waves that (i) increases (ii) remains constant in the electromagnetic spectrum as one moves from radiowave region towards ultraviolet region.

5. How would the angular separation of interference fringes in Young's double slit experiment change when the distance of separation between the slits and the screen is doubled?

6. Calculate the ratio of energies of photons produced due to transition of electron of hydrogen atom from its,

(i) Second permitted energy level to the first level, and

(ii) Highest permitted energy level to the second permitted level.

7. Give expression for the average value of the a c voltage $V = V_0$ Sinw t over the time interval t = 0 and $t = \frac{\pi}{\omega}$.

8. How is the band gap, E_g, of a photodiode related to the maximum wavelength, l_m that can be detected by it?

9. Keeping the voltage of the charging source constant, what would be the percentage change in the energy stored in a parallel plate capacitor if the separation between its plates were to be decreased by 10%?

10. Explain how the average velocity of free electrons in a metal at constant temperature, in an electric field, remain constant even though the electrons are being constantly accelerated by this electric field?

11. How is the resolving power of a microscope affected when,

(i) the wavelength of illuminating radiations is decreased?

(ii) the diameter of the objective lens is decreased? Justify your answer.

12. What is the basic difference between the atom or molecule of a diamagnetic and a paramagnetic material? Why are elements with even atomic number more likely to be diamagnetic?

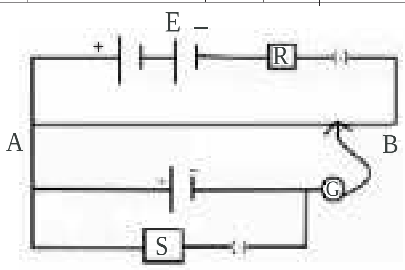
13. Why are infrared radiations referred to as heat waves also? Name the radiations which are next to these radiations in electromagnetic spectrum having

(i) Shorter wavelength. (ii) Longer wavelength.

14. The following data was recorded for values of object distance and the corresponding values of image distance in the experiment on study of real image formation by a convex lens of power +5D. One of these observations is incorrect. Identify this observation and give reason for your choice:

S.No.	1	2	3	4	5	6
Object distance (cm)	25	30	35	45	50	55
Image distance (cm)	97	61	37	35	32	30

15. Two students X and Y perform an experiment on potentiometer separately using the circuit diagram shown here.



Keeping other things unchanged

(i) X increases the value of distance R

(ii) Y decreases the value of resistance S in the set up.

How would these changes affect the position of null point in each case and why?

16. The following table gives the values of work function for a few photosensitive metals

S.No.	Metal	Work Function (eV)
1.	Na	1.92
2.	K	2.15
3.	Mo	4.17

If each of these metals is exposed to radiations of wavelength 300 nm, which of them will not emit photoelectrons and why?

OR

By how much would the stopping potential for a given photosensitive surface go up if the frequency of the incident radiations were to be increased from 4×10^{15} Hz to 8×10^{15} Hz?

Given $h = 6.4 \times 10^{-34}$ Js, $e = 1.6 \times 10^{-19}$ C and $c = 3 \times 10^{8}$ ms^{-1}.

17. Prove that the instantaneous rate of change of the activity of a radioactive substance is inversely proportional to the square of its half life.

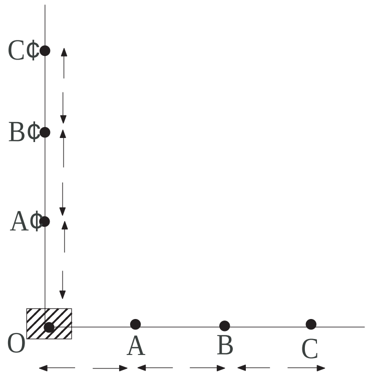
18. What does the term LOS communication mean? Name the types of waves that are used for this communication. Which of the two-height of transmitting antenna and height of receiving antenna - can affect the range over which this mode of communication remains effective?

19. The following data was obtained for the dependence of the magnitude of electric field, with distance, from a reference point O, within the charge distribution in the shaded region.

Field point	A	B	C	A¢	B¢	C¢
Magnitude of electric field	E	E/8	E/27	E2	E16	E/64

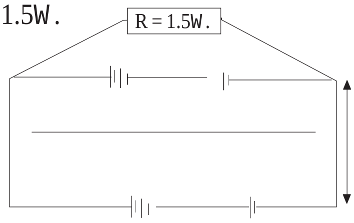
(i) Identify the charge distribution and justify your answer.

(ii) If the potential due to this charge distribution, has a value V at the point A, what is its value at the point A¢?



20. A charge Q located at a point $\vec{r}$ is in equilibrium under the combined electric field of three charges q_1, q_2, q_3. If the charges q_1, q_2 are located at points $\vec{r}_1$ and $\vec{r}_2$ respectively, find the direction of the force on Q, due to q_3 in terms of q_1, q_2, $\vec{r}_1 . \vec{r}_2$ and $\vec{r}$.

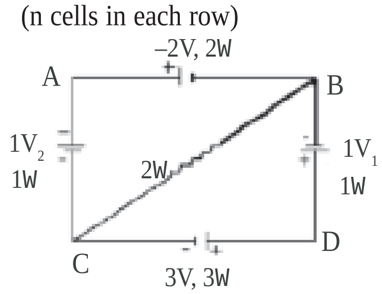
21. 12 cells, each of emf 1.5V and internal resistance 0.5W, are arranged in m rows each containing n cells connected in series, as shown. Calculate the values of n and m for which this combination would send maximum current through an external resistance of 1.5W.



(n cells in each row)

OR

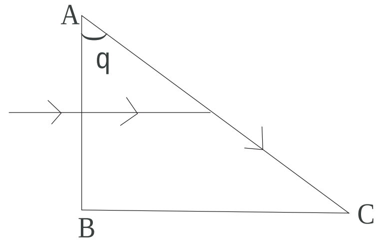
For the circuit shown here, calculate the potential difference be-



tween points B and D.

22. A beam of light of wavelength 400 nm is incident normally on a right angled prism as shown. It is observed that the light just grazes along the surface AC after falling on it. Given that the refractive index of the material of the prism varies with the wavelength λ as per the relation $\mu_A = 1.2 + \frac{b}{\lambda^2}$.

    Calculate the value of b and the refractive index of the prism material for a wavelength $\lambda = 5000$Å [(Given $\theta = \sin^{-1}(0.625)$)]

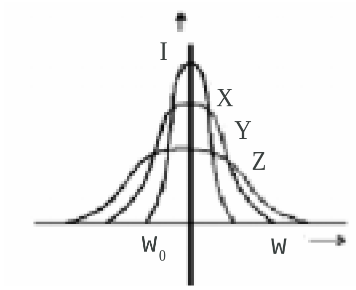


23. Three students X, Y, and Z performed an experiment for studying the variation of alternating currents with angular frequency in a series LCR circuit and obtained the graphs shown below. They all used a.c. sources of the same r. m. s. value and inductances of the same value. What can we (qualitatively) conclude about the

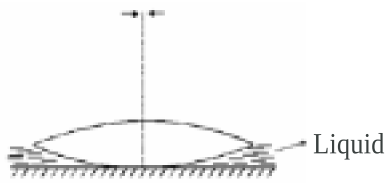
    (i) capacitance value (ii) resistance values

    used by them? In which case will the quality factor be maximum?

    What can we conclude about nature of the impedance of the set up at frequency ω_0?



24. An equiconvex lens with radii of curvature of magnitude r each, is put over a liquid layer poured on top of a plane mirror. A small needle, with its tip on the principal axis of the lens, is moved along the axis until its inverted real image coincides with the needle itself. The distance of the needle from the lens is measured to be 'a'. On removing the liquid layer and repeating the experiment the distance is found to be 'b'. Given that two values of distances measured represent the focal length values in the two cases, obtain a formula for the refractive index of the liquid.



25. A circular coil having 20 turns, each of radius 8 cm, is rotating about its vertical diameter with an angular speed of 50 radian s^{-1} in a uniform horizontal magnetic field of magnitude 30 mT. Obtain the maximum average and r. m. s. values of the emf induced in the coil. If the coil forms a closed loop of resistance 10Ω, how much power is dissipated as heat in it? 3

26. The nucleus of an atom of ${}^{235}_{92}Y$, initially at rest, decays by emitting an α-particle as per the equation ${}^{235}_{92}Y \rightarrow {}^{231}_{90}X + {}^{4}_{2}He + \text{Energy}$.

    It is given that the binding energies per nucleon of the parent and the daughter nuclei are 7.8 MeV and 7.835 MeV respectively and that of α-particle is 7.07MeV/nucleon. Assuming the daughter nucleus to be formed in the unexcited state and neglecting its share in the energy of the reaction, calculate the speed of the emitted α-particle. Take mass of α-particle to be 6.68×10^{-27} kg. 3

27. Define the term 'modulation index' for an AM wave. What would be the modulation index for an AM wave for which the maximum amplitude is 'a' while the minimum amplitude is 'b' ? 3

28. Two circular coils X and Y having radii R and $R/2$ respectively are placed in horizontal plane with their centres coinciding with each other. Coil X has a current I flowing through it in the clockwise sense. What must be the current in coil Y to make the total magnetic field at the common centre of the two coils, zero? With the same currents flowing in the two coils, if the coil Y is now lifted vertically upwards through a distance R, what would be the net magnetic field at the centre of coil Y?

    OR

    A straight thick long wire of uniform cross section of radius 'a' is carrying a steady current I. Use Ampere's circuital law to obtain a relation showing the variation of the magnetic field (Br) inside and outside the wire with distance r, (r £ a) and (r > a) of the field point from the centre of its cross section. Plot a graph showing the nature of this variation. Calculate the ratio of magnetic field at a point $\frac{a}{2}$ above the surface of the wire to that at a point $\frac{a}{2}$ below its surface. What is the maximum value of the field of this wire? 5

29. State the principle which helps us to determine the shape of the wavefront at a later time from its given shape at any time. Apply this principle to

(i) Show that a spherical/ plane wavefront continues to propagate forward as a spherical/plane wavefront.

(ii) Derive Snell's law of refraction by drawing the refracted wavefront corresponding to a plane wavefront incident on the boundary separating a rarer medium from a denser medium. 5

OR

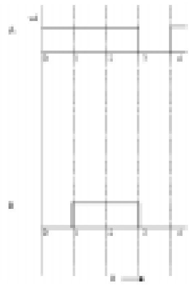
(a) What do we understand by 'polarization' of a wave? How does this phenomenon help us to decide whether a given wave is transverse or longitudinal in nature?

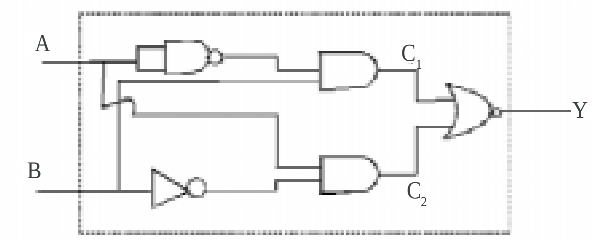
(b) Light from an ordinary source (say a sodium lamp) is passed through a polaroid sheet P_1 .The transmitted light is then made to pass through a second polaroid sheet P_2 which can be rotated so that the angle (q) between the two polaroid sheets varies from 0^0 to 90^o. Show graphically the variation of the intensity of light, transmitted by P_1 and P_2, as a function of the angle q . Take the incident beam intensity as I_0. Why does the light from a clear blue portion of the sky, show a rise and fall of intensity when viewed through a polaroid which is rotated? 5

30. A student has to study the input and output characteristics of an n-p-n silicon transistor in the Common Emitter configuration. What kind of a circuit arrangement should she use for this purpose? Draw the typical shape of input characteristics likely to be obtained by her. What do we understand by the cut off, active and saturation states of the transistor? In which of these states does the transistor not remain when being used as a switch?

OR

Input signals A and B are applied to the input terminals of the 'dotted box' set-up shown here. Let Y be the final output signal from the box. Draw the wave forms of the signals labelled as C_1 and C_2 within the box, giving (in brief) the reasons for getting these wave forms. Hence draw the wave form of the final output signal Y. Give reasons for your choice. What can we state (in words) as the relation between the final output signal Y and the input signals A and B ?



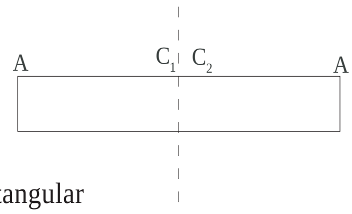


SET II

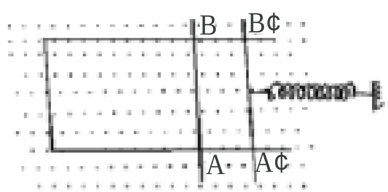
General instructions same as set 1

1. What is the angle between the directions of electric field at any (i) axial point and (ii) equatorial point due to an electric dipole? 1

2. A (hypothetical) bar magnet (AB) is cut into two equal parts. One part is now kept over the other, so that pole C_2 is above C_1. If M is the magnetic moment of the original magnet, what would be the magnetic moment of the combination so formed? 1



3. A rectangular wire frame, shown below, is placed in a uniform magnetic field directed upward and normal to the plane of the paper. The part AB is connected to



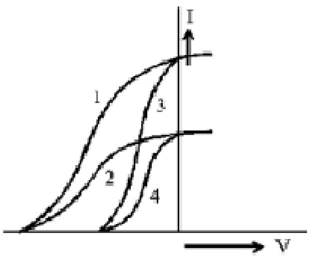
a spring. The spring is stretched and released when the wire AB has come to the position A¢B¢(t = 0). How would the induced emf vary with time? Neglect damping. 1

4. From the following, identify the electromagnetic waves having the (i) Maximum (ii) Minimum frequency. 1

   (i) Radio waves (ii) Gamma-rays (iii) Visible light (iv) Microwaves (v) Ultraviolet rays, and (vi) Infrared rays.

5. A partially plane polarised beam of light is passed through a polaroid. Show graphically the variation of the transmitted light intensity with angle of rotation of the polaroid.

6. The given graphs show the variation of photo electric current (I) with the applied voltage (V) for two different materials and for two different intensities of the incident radiations.

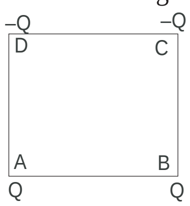


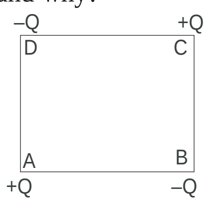
   Identify the pairs of curves that correspond to different materials but same intensity of incident radiations.

7. Four nuclei of an element fuse together to form a heavier nucleus. If the process is accompanied by release of energy, which of the two - the parent or the daughter nucleus would have a higher binding energy/nucleon?

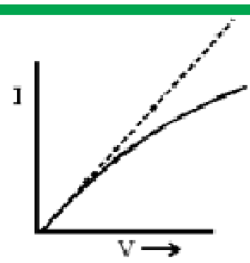
8. Zener diodes have higher dopant densities as compared to ordinary p-n junction diodes. How does it affect the (i) Width of the depletion layer? (ii) Junction field?

9. Four point charges are placed at the four corners of a square in the two ways (i) and (ii) as shown below. Will the (i) electric field (ii) Electric potential, at the centre of the square, be the same or different in the two configurations and why?





10. The I-V characteristics of a resistor are observed to deviate from a straight line for higher values of current as shown below. Why?



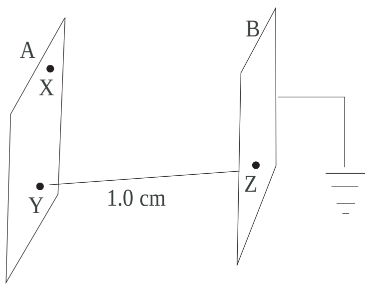
11. A charged particle moving with a uniform velocity $\vec{V}$ enters a region where uniform electric and magnetic fields $\vec{E}$ and $\vec{B}$ are present. It passes through the region without any change in its velocity. What can we conclude about the

    (i) Relative directions of $\vec{E}, \vec{V}$ and $\vec{B}$?

    (ii) Magnitudes of $\vec{E}$ and $\vec{B}$?

12. Figure shows two long coaxial solenoids, each of length 'l'. The outer soleniod has an area of cross-section A and number of turns/ length n_1. The corresponding values for the inner solenoid are A_2 and n_2. Write the expression for self inductance L_1, L_2 of the two coils and their mutual inductance M. Hence show that $M < \sqrt{L_1 L_2}$.

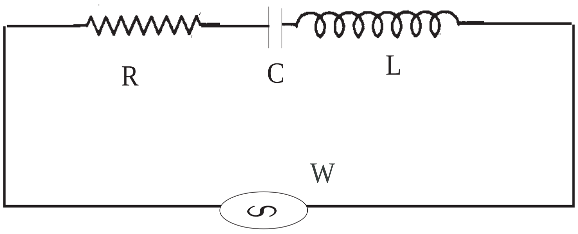
13. Two identical plane metallic surfaces A and B are kept parallel to each other in air separated by a distance of 1.0 cm as shown in the figure.



    Surface A is given a positive potential of 10V and the outer surface of B is earthed. (i) What is the magnitude and direction of the uniform electric field between points Y and Z? (ii) What is the work done in moving a charge of 20 mC from point X and point Y?

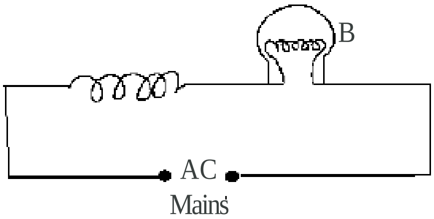
14. In the circuit shown below, R represents an electric bulb. If the frequency u of the supply is doubled,

how should the values of C and L be changed so that the glow in the bulb remains unchanged?



OR

An air cored coil L and a bulb B are connected in series to the ac mains as shows in the given figure :



The bulb glows with some brightness. How would the glow of the bulb change if an iron rod were inserted in the coil? Give reasons in support of your answer. 2

15. Experimental observations have shown that X-rays (i) travel in vacuum with a speed of 3×10^8 ms^{-1}, (ii) exhibit the phenomenon of diffraction and can be polarized.
What conclusions can be drawn about the nature of X-rays from each of these observations? 2

16. Write the relation between the angle of incidence (i), the angle of emergence (e), the angle of prism (A) and the angle of deviation (d) for rays undergoing refraction through a prism. What is the relation between Ð i and Ð e for rays undergoing minimum deviation? Using this relation, write the expression for the refractive index (m) of the material of a prism in terms of Ð A and the angle of minimum deviation (dm). 2

17. A radioactive material is reduced to $\frac{1}{16}$ of its original amount in 4 days. How much material should one begin with so that 4×10^{-3} kg of the material is left after 6 days. 2

18. Distinguish between 'point to point' and 'broadcast' communication modes. Give one example of each. 2

19. In a double slit interference experiment, the two coherent beams have slightly different intensities I and I + dI (dI << I). Show that the resultant intensity at the maxima is nearly 4I while that at the minima is nearly $\frac{(\delta I)^2}{4I}$.

20. An electric dipole of dipole moment $\vec{p}$ is placed in a uniform electric field $\vec{E}$. Write the expression for the torque $\vec{\tau}$ experienced by the dipole. Identify two pairs of perpendicular vectors in the expression. Show diagramatically the orientation of the dipole in the field for which the torque is (i) maximum (ii) half the maximum value (iii) zero.

OR

Two capacitors with capacity C_1 and C_2 are charged to potential V_1 and V_2 respectively and then connected in parallel. Calculate the common potential across the combination, the charge on each capacitor, the electrostatic energy stored in the system and the change in the electrostatic energy from its initial value. 3

21. Using a suitable combination from a NOR, an OR and a NOT gate, draw circuits to obtain the truth table given below:

A	B	Y
0	0	0
0	1	0
1	0	1
1	1	0

(i)

A	B	Y
0	0	1
0	1	1
1	0	0
1	1	1

(ii)

22. Which two main considerations are kept in mind while designing the 'objective' of an astronomical telescope? Obtain an expression for the angular magnifying power and the length of the tube of an astronomical telescope in its 'normal adjustment' position. 3

23. Calculate the de-Broglie wavelength of (i) an electron (in the hydrogen atom) moving with a speed of $\frac{1}{100}$ of the speed of light in vacuum and (ii) a ball of radius 5mm and mass 3×10^{-2} kg moving with a speed of $100ms^{-1}$. Hence show that the wave nature of matter is important at the atomic level but is not really relevant at the macroscopic level. 3

24. Show that during the charging of a parallel plate capacitor, the rate of change of charge on each plate equals e_0 times the rate of change of electric flux (f_E) linked with it. What is the name given to the term $\varepsilon_0 \frac{d\phi_E}{dt}$? 3

25. The spectrum of a star in the visible and the ultraviolet region was observed and the wavelength of some of the lines that could be identified were found to be :
824Å, 970Å, 1120Å, 2504Å, 5173Å, 6100Å.
Which of these lines cannot belong to hydrogen atom spectrum? (Given Rydberg constant $R = 1.03 \times 10^7 m^{-1}$ and $\frac{1}{R} = 970$Å. Support your answer with suitable calculations. 3

26. What is space wave propagation? Which two communication methods make use of this mode of propagation? If the sum of the heights of transmitting and receiving antennae in line of sight of communication is fixed at h, show that the range is maximum when the two antennae have a height $\frac{h}{2}$ each.

27. Draw the transfer characteristics of a base biased transistor in its common emitter configuration. Explain briefly the meaning of the term 'active region' in these characteristics. For what practical use, do we use the transistor in this 'active region'?

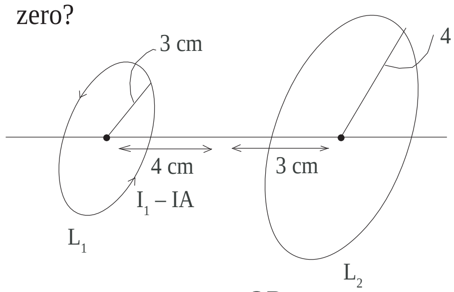
28. A cell of unknown emf E and internal resistance r, two unknown resistances R_1 and R_2 ($R_2 > R_1$) and a perfect ammeter are given. The current in the circuit is measured in five different situations : (i) Without any external resistance in the circuit, (ii) With resistance R_1 only, (iii) With resistance R_2 only, (iv) With both R_1 and R_2 used in series combination and (v) With R_1 and R_2 used in parallel combination. The current obtained in the five cases are 0.42A, 0.6A, 1.05A, 1.4A, and 4.2A, but not necessarily in that order. Identify the currents in the five cases listed above and calculate E, r,, R_1 and R_2.

OR

Describe the formula for the equivalent EMF and internal resistance for the parallel combination of two cells with EMF E_1 and E_2 and internal resistances r_1 and r_2 respectively. What is the corresponding formula for the series combination? Two cells of EMF 1V, 2V and internal resistances 2W and 1W respectively are connected in (i) series, (ii) parallel. What should be the external resistance in the circuit so that the current through the resistance be the same in the two cases? In which case more heat is generated in the cells ? 5

29. (i) Describe an expression for the magnetic field at a point on the axis of a current carrying circular loop.

(ii) Two coaxial circular loops L_1 and L_2 of radii 3cm and 4cm are placed as shown. What should be the magnitude and direction of the current in the loop L_2 so that the net magnetic field at the point O be zero?



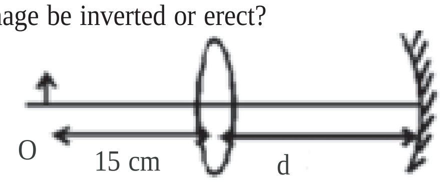
OR

(i) What is the relationship between the current and the magnetic moment of a current carrying circular loop? Use the expression to derive the relation between the magnetic moment of an electron moving in a circle and its related angular momentum?

(ii) A muon is a particle that has the same charge as an electron but is 200 times heavier than it. If we had an atom in which the muon revolves around a proton instead of an electron, what would be the magnetic moment of the muon in the ground state of such an atom?

30. (i) Derive the mirror formula which gives the relation between f, v and u. What is the corresponding formula for a thin lens?

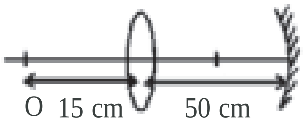
(ii) Calculate the distance d, so that a real image of an object at O, 15cm in front of a convex lens of focal length 10cm be formed at the same point O. The radius of curvature of the mirror is 20cm. Will the image be inverted or erect?



OR

(i) Using the relation for refraction at a single spherical refracting surface, derive the lens maker's formula.

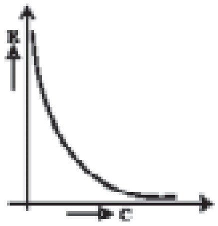
(ii) In the accompanying diagram, the direct image formed by the lens (f = 10cm) of an object placed at O and that formed after reflection from the spherical mirror are formed at the same point O' . What is the radius of curvature of the mirror?



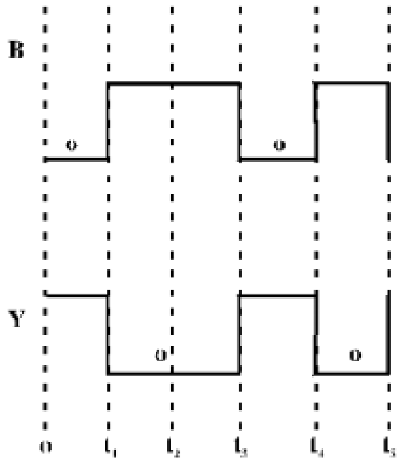
SET III

General instructions same as set 1.

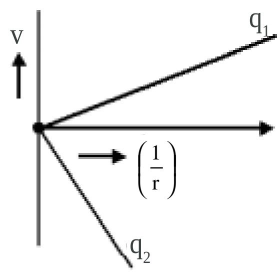
1. The graph shown here, shows the variation of the total energy (E) stored in a capacitor against the value of the capacitance (C) itself. Which of the two - the charge on the capacitor or the potential used to charge it is kept constant for this graph?



2. An α- particle and a proton are moving in the plane of the paper in a region where there is a uniform magnetic field ($\vec{B}$) directed normal to the plane of the paper. If the two particles have equal linear momenta, what will be the ratio of the radii of their trajectories in the field? 1
3. State the condition under which a microwave oven heats up a food item containing water molecules most efficiently.
4. An electrical element X, when connected to an alternating voltage source, has the current through it leading the voltage by $\frac{\pi}{2}$ radii. Identify X and write an expression for its reactance. 1
5. A double convex lens, made from a material of refractive index μ_1, is immersed in a liquid of refractive index where $\mu_2 > \mu_1$. What change, if any, would occur in the nature of the lens? 1
6. The de Broglie wavelengths, associated with a proton and a neutron, are found to be equal. Which of the two has a higher value for kinetic energy? 1
7. Carbon and silicon are known to have similar lattice structures. However, the four bonding electrons of carbon are present in second orbit while those of silicon are present in its third orbit. How does this difference result in a difference in their electrical conductivities? 1
8. An unknown input (A) and the input (B) shown here, are used as the two inputs in a NAND gate. The output Y, has the form shown below. Identify the intervals over which the input 'A' must be 'low'.



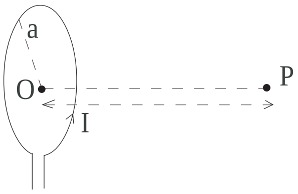
9. The two graphs drawn below, show the variation of electrostatic potential (V) with $\frac{1}{r}$ (r being distance of the field point from the point charge) for two point charges q_1 and q_2.
(i) What are the signs of the two charges?
(ii) Which of the two charges has a larger magnitude and why? 2



10. Calculate the temperature at which the resistance of a conductor becomes 20% more than its resistance at 27^{0}C.The value of the temperature coefficient of resistance of the conductor is 2.0×10^{-4}/K. 2
11. A student records the following data for the magnitudes (B) of the magnetic field at axial points at different distances x from the centre of a circular coil of radius a carrying a current I. Verify (for any two)

that these observations are in good agreement with the expected theoretical variation of B with x.

x®	x = 0	x = a	x = 2a	x = 3a
B®	B_0	$0.25\sqrt{2}B_0$	$0.039\sqrt{5}B_0$	$0.010\sqrt{10}B_0$



12.An armature coil consists of 20 turns of wire, each of area A = 0.09m^2 and total resistance 15.0W. It rotates in a magnetic field of 0.5T at a constant frequency of $\frac{150}{\pi}$Hz. . Calculate the value of (i) maximum (ii) average induced emf produced in the coil. 2

13. Two cells of emf E_1 and E_2 have internal resistance r_1 and r_2. Deduce an expression for equivalent emf of their parallel combination.

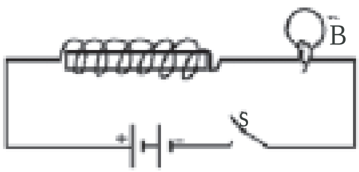
OR

A cell of emf (E) and internal resistance (r) is connected across a variable external resistance (R). Plot graphs to show variation of

(i) E with R ,

(ii) Terminal p.d. of the cell (V) with R

14. Fig. shows a light bulb (B) and iron cored inductor connected to a DC battery through a switch (S). 2



(i) What will one observe when switch (S) is closed?

(ii) How will the glow of the bulb change when the battery is replaced by an ac source of rms voltage equal to the voltage of DC battery? Justify your answer in each case.

15. Electromagnetic radiations with wavelength 2

(i) l_1 are used to kill germs in water purifiers.

(ii) l_2 are used in TV communication systems.

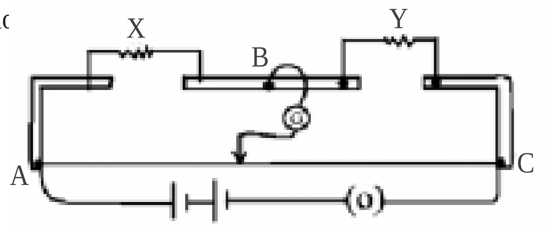
(iii) l_3 play an important role in maintaining the earth's warmth. Name the part of electromagnetic spectrum to which these radiations belong. Arrange these wavelengths in decreasing order of their magnitude.

16.What do the terms 'depletion region' and 'barrier potential' mean for a p-n junction? 2

17. We do not choose to transmit an audio signal by just directly converting it to an e.m. wave of the same frequency. Give two reasons for the same. 2

18. Light of wavelength 550 nm. is incident as parallel beam on a slit of width 0.1mm. Find the angular width and the linear width of the principal maxima in the resulting diffraction pattern on a screen kept at a distance of 1.1m from the slit. Which of these widths would not change if the screen were moved to a distance of 2.2m from the slit? 2

19. The given figure shows the experimental set up of a metre bridge. The null point is found to be 60cm away from the end A with X and Y in position as sho



When a resistance of 15W is connected in series with 'Y', the null point is found to shift by 10cm towards the end A of the wire. Find the position of null point if a resistance of 30W were connected in parallel with 'Y'. 3

OR

Why is a potentiometer preferred over a voltmeter for determining the emf of a cell? Two cells of emf E_1 and E_2 are connected together in two ways shown here.

The 'balance points' in a given potentiometer experiment for these two combinations of cells are found to be at 351.0cm and 70.2cm respectively. Calculate the ratio of the Emfs of the two cells.

20. When a circuit element 'X' is connected across an a.c. source, a current of $\sqrt{2}$ A flows through it and this current is in phase with the applied voltage. When another element 'Y' is connected across the same a.c. source, the same current flows in

the circuit but it leads the voltage by $\frac{\pi}{2}$ radians.

(i) Name the circuit elements X and Y.

(ii) Find the current that flows in the circuit when the series combination of X and Y is connected across the same a.c. voltage.

(iii) Plot a graph showing variation of the net impedance of this series combination of X and Y as a function of the angular frequency ω of the applied voltage. 3

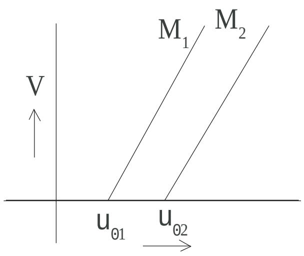
21. Give reasons for the following : 3

(a) Astronomers prefer to use telescopes with large objective diameters to observe astronomical objects.

(b) Two identical but independent monochromatic sources of light cannot be coherent.

(c) The value of the Brewster angle for a transparent medium is different for lights of different colours.

22. The given graphs show the variation of the stopping potential V_s with the frequency (ν) of the incident radiations for two different photosensitive materials M_1 and M_2.



(i) What are the values of work functions for M_1 and M_2 ?

(ii) The values of the stopping potential for M_1 and M_2 for a frequency ν_3 ($> \nu_{02}$) of the incident radiations are V_1 and V_2 respectively. Show that the slope of the lines equals $\frac{V_1 - V_2}{\nu_{02} - \nu_{01}}$. 3

23. What is a wavefront? Distinguish between a plane wavefront and a spherical wavefront. Explain with the help of a diagram, the refraction of a plane wavefront at a plane surface using Huygen's construction. 3

24. Define the term 'Activity' of a radioactive substance. State its SI unit. Two different radioactive elements with half lives T_1 and T_2 have N_1 and N_2 (undecayed) atoms respectively present at a given instant. Determine the ratio of their activities at this instant. 3

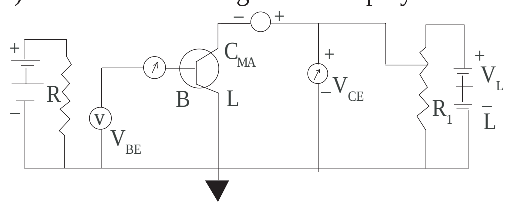
25. (a) Draw the block diagram of a communication system.

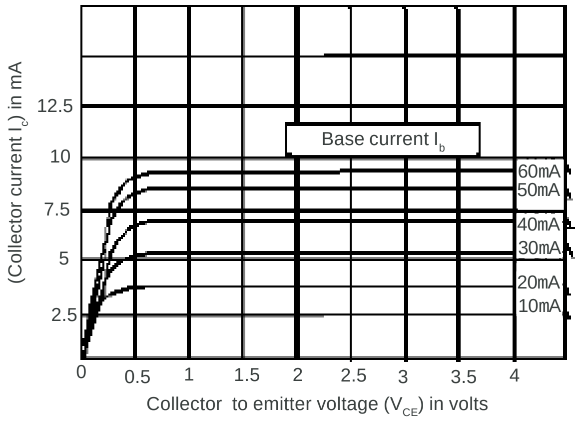
(b) What is meant by 'detection' of a modulated carrier wave? Describe briefly the essential steps for detection. 3

26. The given circuit diagram shows a transistor configuration along with its output characteristics. Identify

(i) the type of transistor used and

(ii) the transistor configuration employed.

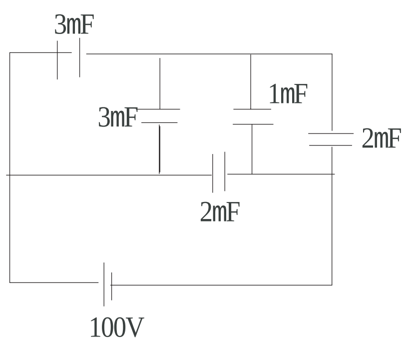




Use these graphs to obtain the approximate value of current amplification factor for the transistor at $V_{CE} = 3V$. 3

27. State Bohr's postulate for the 'permitted orbits' for the electron in a hydrogen atom. Use this postulate to prove that the circumference of the nth permitted orbit for the electron can 'contain' exactly n wavelengths of the deBroglie wavelength associated with the electron in that orbit. 3

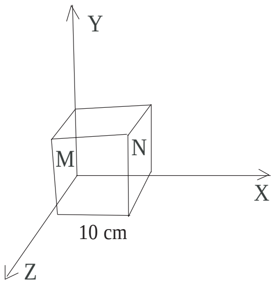
28. Obtain an expression for the capacitance of a parallel plate (air)capacitor. The given figure shows a network of



five capacitors connected to a 100V supply. Calculate the total charge and energy stored in the network.

OR

(a) Use Gauss's law to obtain an expression for the electric field due to an infinitely long straight uniformly charged wire.



(b) Electric field in the above figure is directed along + X direction and given by Ex = 5Ax + 2B, where E is in NC^{-1} and x is in metre, A and B are constants with dimensions Taking A = $10NC^{-1}m^{-1}$ and B = $5NC^{-1}$. calculate:
(i) the electric flux through the cube.
(ii) net charge enclosed within the cube. 5

29. (a) Draw the labelled diagram of moving coil galvanometer. Prove that in a radial magnetic field, the deflection of the coil is directly proportional to the current flowing in the coil.
(b) A galvanometer can be converted into a voltmeter to measure up to
(i) 'V' volts by connecting a resistance R_1 in series with coil.
(ii) $\frac{V}{2}$ volts by connecting a resistance R_2 in series with its coil. Find the resistance (R), in terms of R_1 and R_2 required to convert it into a voltmeter that can read up to '2V' volts.

OR

(a) Draw diagrams to depict the behaviour of magnetic field lines near a ' bar' of:
(i) copper (ii)Aluminium
(iii) Mercury, cooled to a very low temperature (4.2K)
(b) The vertical component of the earth's magnetic field at a given place is $\sqrt{3}$ times its horizontal component. If total intensity of earth's magnetic field at the place is 0.4 G, find the value of :
(i) angle of dip
(ii) the horizontal component of earth's magnetic field.

30. (a) Draw a ray diagram to show the refraction of light through a glass prism. Hence obtain the relation for the angle of deviation in terms of the angle of incidence, angle of emergence and the angle of the prism.
(b) A right angled isosceles glass prism is made from glass of refractive index 1.5. Show that a ray of light incident normally on
(i) one of the equal sides of this prism is deviated through 90°
(ii) the hypotenuse of this prism is deviated through 180°.

OR

(a) With the help of a labelled ray diagram, show the image formation by a compound microscope. Derive an expression for its magnifying power.
(b) How does the resolving power of a compound microscope get affected on
(i) decreasing the diameter of its objective?
(ii) increasing the focal length of its objective?

Answers

SET I

1. 1 : 1
2. Large induced current is produced due to electromagnetic induction which heats up the metallic piece.
3. The charge of the 'excess' charge carriers gets balanced by an equal and opposite charge of the ionized cores in the lattice.
4. (i) Frequency (ii) Speed in free space
5. No effect

(or the angular separation remains the same).

6. We have

$$E_{2\to1} = \text{const.}\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \text{const.}\frac{3}{4}$$

$$\text{and } E_{\infty\to2} = \text{const.}\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right) = \text{const.}\frac{1}{4}$$

$\therefore$ Ratio = 3 : 1

7. $\frac{2V_0}{\pi}$ or $\frac{7}{11}V_0$

8. We have $\frac{hc}{\lambda_m} = E_g$ or $\lambda_m = \frac{hc}{E_g}$

9. $E = \frac{1}{2}CV^2 = \frac{1}{2}\frac{\epsilon_0 A}{d}V^2$

$\therefore \frac{E_2}{E_1} = \frac{d_1}{d_2} = \frac{100}{90} = \frac{10}{9}$

$\therefore \frac{\Delta E}{E_1} = \frac{E_2 - E_1}{E_1} = \left(\frac{10}{9} - 1\right) \times 100\%$ = 11.1%

10. We have $\vec{V}_t = \vec{V}_i + \frac{eE}{m}t \;\therefore\; |\vec{V}_t|_{AV} = |\vec{V}_i|_{AV} + \frac{eE}{m}t_{AV}$

$|\vec{V}_i|_{AV}$ = zero (Random nature of motion and collisions). $\therefore$ $|\vec{V}_t|_{AV} = \frac{eE}{m}\tau$ = constant

as τ, the average time between collisions, remains contant under constant temprature conditions.

11. (i) It increases (ii) It decreases

12. The atom/molecule of a diamagnetic material has zero net magnetic moment. For a paramagnetic material it is not so. With an even atomic number, the electrons in an atom of an element can 'pair off', which can makes the net magnetic moment of each pair as zero. This makes the element more likely to be diamagnetic.

13. Infrared radiations get readily absorbed by water molecules in most materials. This increases their thermal motion and heats them up.
(i) visible light (ii) Microwaves

14. Focal length of the lens = $\frac{1}{5} \times 100$ cm = 20 cm

Obervation at 3 is incorrect .
This observation is incorrect because for an object distance lying between f and 2f, the image distance has to be more than 2f.

15. For student X, the null point would shift towards right (i.e. towards B) [Increase in R decreases the potential gradient. Hence a greater length of wire would be needed for balancing the same emf. For student Y, the null point would shift towards left (ie. toward A) [A decrease of S would decrease the terminal p.d.V across the unknown battery (V = E - ir and $i\left(= \frac{E}{r+S}\right)$ increases as S decreases, and hence a smaller length (for the same potential gradient) would be needed for balancing it]

16. Energy of a photon of the incident radiation = $\frac{hc}{\lambda}$

$= \frac{6.4 \times 10^{-34} \times 3 \times 10^8}{300 \times 10^{-9} \times 1.6 \times 10^{-19}} eV = 4eV$

This being less than the work function of Mo, there would be no photo-emission from Mo.

OR

$eV_s = h\nu - W \;\therefore\; e(V_2 - V_1) = h(\nu_2 - \nu_1)$

or $V_2 - V_1 = \frac{h}{e}(\upsilon_2 - \upsilon_1)$

$\therefore V_2 - V_1 = \frac{6.4 \times 10^{-34}}{1.6 \times 10^{-19}}(8-4) \times 10^{15}$ volt = 16 volt

17. Instantaneous Activity = $R = \frac{dN}{dt} = \lambda N$

$\therefore \frac{dR}{dt} = \frac{d}{dt}(\lambda N) = \lambda \frac{dN}{dt}$

$\lambda(-\lambda N) = -\lambda^2 N = -\left(\frac{\log_e 2}{T_{1/2}}\right)^2 N \;\therefore\; \frac{dR}{dt} \propto \frac{1}{(T_{1/2})^2}$

18. LOS → line of sight
Waves used → space waves
It is both - the height of transmitting antenna as well as the height of the receiving antenna that affects the range of the mode of communication.

19. We observe that the field magnitude (i) Varies as the inverse cube of the distance of the field point along one line. (ii) Has a magnitude half of its magnitude (at an equidistant point) on the line perperdicular to this line. These properties tell us that the given charge distribution is a (small) electric dipole centered at the reference point O. The point A' is an equatorial points for the given dipole. Hence potential of A′= zero.

20. We have $\vec{F}_1 = \frac{1}{4\pi\epsilon_0}\frac{Qq_1}{|\vec{r} - \vec{r}_1|^3}(\vec{r} - \vec{r}_1)$

and $\vec{F}_2 = \frac{1}{4\pi\epsilon_0}\frac{Qq_2}{|\vec{r} - \vec{r}_2|^3}(\vec{r} - \vec{r}_2)$

For equilibrium, we must have $\vec{F}_3 = \vec{F}_1 + \vec{F}_2 = 0$

or $\vec{F}_3 = -(\vec{F}_1 + \vec{F}_2)$

Hence $\vec{F}_3 = \dfrac{Q}{4\pi\epsilon_0}\left[\dfrac{q_1}{|\vec{r}-\vec{r}_1|^3}(\vec{r}_1-\vec{r})+\dfrac{q_2(\vec{r}_2-\vec{r})}{|\vec{r}-\vec{r}_2|^3}\right]$

$\therefore$ The direction of $\vec{F}_3$ is given by the direction of the vector $\left[\dfrac{q_1}{|\vec{r}-\vec{r}_1|^3}(\vec{r}_1-\vec{r})+\dfrac{q_2}{|\vec{r}-\vec{r}_2|^3}(\vec{r}_2-\vec{r})\right]$

21. The equivalent internal resistance of each row of n cells in series = nr. The net equivalent internal resistance of the combination = $\dfrac{nr}{m}$

Net equivalent emf of the combination = n × E (E = emf of one cell)

$\therefore$ Current drawn by R = $\dfrac{nE}{R+\dfrac{nr}{m}} = \dfrac{mnE}{mR+nr} = \dfrac{NE}{mR+nr}$

$$= \dfrac{NE}{\left(\sqrt{mR}-\sqrt{nr}\right)^2+\sqrt{2mnRr}}$$

$$= \dfrac{NE}{\left(\sqrt{mR}-\sqrt{nr}\right)^2+\sqrt{2\,NRr}}$$

For maximum current, the denominator should be minimum.

This happens when, $\sqrt{mR}=\sqrt{nr}$ or $R=\dfrac{nr}{m}$

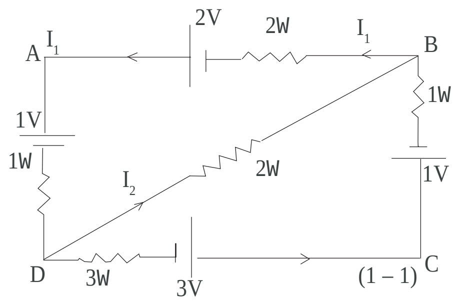
$\therefore$ $\dfrac{n\times 0.5}{m}=1.5$ or $\dfrac{n}{m}=3$

Also n × m = 12 (given)

Solving, we get n = 6 and m = 2

OR

We can draw the circuit explicitly as shown. The current distribution can be taken as shown. Applying Kirchhoff's second law to loops BADB and DCBD, respectively, we get the equations:



$-2I_1 + 2 - 1 - 1\times I_1 - 2I_2 = 0$ or $3I_1 + 2I_2 = 1$

and, $-3(I_1 - I_2) + 3 - 1 - 1\times(I_1 - I_2) + 2I_2 = 0$

or $4I_1 - 6I_1 = 2$

Solving, we get $I_1 = \dfrac{5}{13}$A and $I_2 = \dfrac{1}{13}$A

P.d. between B and D = $2\times\dfrac{1}{13}V = \dfrac{2}{13}V = 0.154V$

(Point B is at a higher potential w. r. t. point D)

22. The ray must fall on the surface AC at just the critical angle, θ_c. The angle of incidence at the face AC equals θ.

Hence $\theta = \theta_c$.

$\therefore \mu = \dfrac{1}{\sin\theta_c} = \dfrac{1}{0.625} = 1.6 \quad \therefore \quad 1.6 = 1.2 + \dfrac{b}{\left(4\times10^{-7}\right)^2}$

$\therefore$ b = 0.4 × 16 × $10^{-14}m^2$ = 6.4 × 10^{-14} m^2

The refractive index for λ =5000 Å is given by

$\mu' = 1.2 + \dfrac{6.4\times10^{-14}}{\left(5\times10^{-7}\right)^2} = 1.2 + \dfrac{6.4}{25}$

= 1.2 + 0.256 = 1.456

23. (i) We have $C_1 = C_2 = C_3$

Resonant frequency = $\dfrac{1}{2\pi\sqrt{LC}}$ is same for all three and we are given that L has same value for all.

(ii) We have $R_1 < R_2 < R_3$. Bandwidth for X< B and width for Y< Bandwidth for Z. Max.current for X >Max. current for Y > Max.current for Z. Student X has the maximum value for the quality factor because the bandwidth is least in this case. The impedance at the resonant frequency ω_0 is purely resistive in nature.

24. The liquid layer can be regarded as forming a plane concave lens.The first value (= a) of the measured distance is, therefore, the focal length of the combination of the given lens and the liquid lens. The second value (=b) represents the focal length of the lens itself. Hence, if f = 16 is the focal length of the liquid lens, we have

$\dfrac{1}{a}=\dfrac{1}{b}+\dfrac{1}{f}$ or $\dfrac{1}{f}=\dfrac{1}{a}-\dfrac{1}{b}=\left(\dfrac{b-a}{ab}\right)$

But, $\dfrac{1}{f}=(\mu-1)\left(-\dfrac{1}{R}+\dfrac{1}{\infty}\right)=\left(\dfrac{\mu-1}{-R}\right)$

$\therefore \ \frac{(b-a)}{ab} = \frac{(\mu-1)}{-R}, \ \mu = \frac{R(a-b)}{ab} + 1$

25. When the normal to the plane of the coil makes an angle with the direction of the magnetic field, the flux linked with it is ϕ = NBA cos θ = NBA cosωt

$\therefore$ Induced Emf = $\frac{d\phi}{dt} = NBA\ \omega \sin \omega t$

$\therefore$ Max. Emf = NBA ω = NB (πr^2)ω

= 20 × 30 × 10^{-3} × π (8 × 10^{-2})^2 × 50 volt

= 0.603 volt

Average Emf = Average of Sinωt over a cycle = Zero

rms value of Emf = $\frac{\text{Max. Emf}}{\sqrt{2}} = \frac{0.603}{\sqrt{2}}$ volt

= 0.426V

Power dissipated = $\frac{(E_{rms})^2}{R} = \frac{(0.426)^2}{10} W = 0.018W$

26. Total B.E. of parent Nucleus = 7.8 × 235 MeV

= 1833 MeV

Total B.E. of daughter nucleus

= 7.835 × 231 MeV = 1809.9MeV

Total B.E. of α-particle = 7.07 × 4 MeV

= 28.28 MeV

Increase in B.E. after the reaction

= [(180.9 + 28.28) - (1833)]MeV = 5.18 MeV

This is the energy released in the reaction, since it assumed to be taken up totally by the α-particle,

$\frac{1}{2}mv^2$ = 5.18 × 1.6 × 10^{-13} J

$v^2 = \frac{5.18 \times 3.2}{6.68} \times 10^{14} m^2 s^{-2} = \sqrt{2.48} \times 10^7 ms^{-1}$

= 1.58 × 10^7 ms^{-1}

27. The modulation index (μ) for an AM wave equals the ratio of the peak value of the modulating signal (A_m) to the peak value of the carrier wave (A_c)

$\mu = \frac{A_m}{A_C}$

Given that $a = A_c + A_m$ and $b = A_c - A_m$

$\therefore \ A_c = \frac{a+b}{2}$ and $A_m = \frac{a-b}{2}$ $\therefore$ $\mu = \frac{a-b}{a+b}$

28. We have $\vec{B}_x = -\vec{B}_y$

$\therefore \ \frac{\mu_0 I}{2R} = \frac{\mu_0 I'}{2.R/2}$ or I¢= I/2

The coil Y must carry this current in the anticlock wise sense. When the coil Y is lifted through a distance R, its centre becomes an axial point for coil X. Hence

$$Bx' = \frac{\mu_0 IR^2}{2(R^2+R^2)^{3/2}} = \frac{\mu_0 I}{4\sqrt{2}R} = \frac{\mu_0 I\sqrt{2}}{8R}$$

Also $By' = \frac{\mu\ 1/2}{2\ R/2} = \frac{\mu_0 I}{2R}$

$\therefore$ Magnitude of net field

$$= By' - Bx' = \frac{\mu_0 I}{2R}\left(1 - \frac{\sqrt{2}}{4}\right) = = 0.323\frac{\mu_0 I}{R}$$

This net field is in the direction of the field due to the coil Y, i.e; perpendicular to its plane and directed vertically upwards.

OR

Consider a closed path of radius r inside the cross section of the wire. The current enclosed by this path is $I' = \left(\frac{I}{\pi a^2}\right)\pi r^2 = I\frac{r^2}{a^2}$

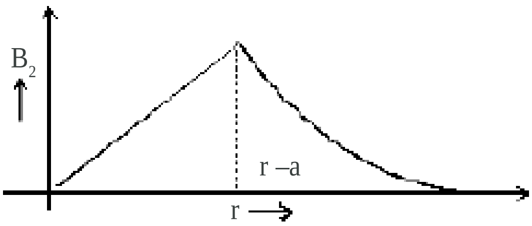
By Ampere's circuital law, $\oint \vec{B}_r.d\vec{l} = \mu_0 I'$

or $B_r 2\pi r = \mu_0 I \frac{r^2}{a^2}$ $\therefore$ $B_r = \frac{\mu_0 I}{2\pi a^2} r$ or $B \propto r$ (for $r < a$)

Outside the wire, the field of the wire is given by

B.2πr = μ_0 I or $B = \frac{\mu_0 I}{2\pi r}$ $(r > a)$

The relevant graph is, therefore, as shown.



If B_1 and B_2, denote respectively, the values of the magnetic field at points $\frac{a}{2}$ above and $\frac{a}{2}$ below the surface of the wire, we have

$$B_1 = \frac{\mu_0 I}{2\pi\left(3\frac{a}{2}\right)} = \frac{\mu_0 I}{3\pi a} \text{ and } B_2 = \frac{\mu_0 I}{2\pi a^2} = \frac{a}{2} = \frac{\mu_0 I}{4\pi a}$$

$$\therefore \frac{B_1}{B_2} = \frac{4}{3}$$

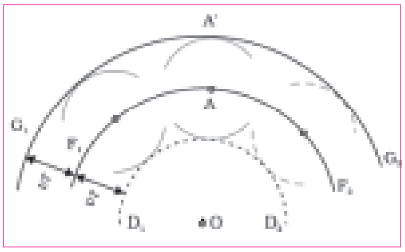
The maximum value of the field is at r = a.

we have $B_{max} = \frac{\mu_0 I}{2\pi a}$

29. The scientist Huygens gave a hypothesis for geometrical construction of the position of common wavefront at any instant during the propagation of waves. The postulates are:

(a) Every point on the given wavefront called primary wavefront acts as a fresh source of light called secondary wavelets, which travel in all directions with the velocity of light in the medium.

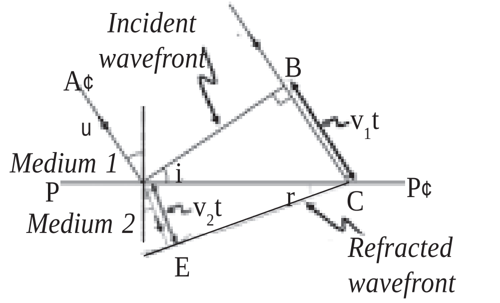
(b) A surface touching these secondary wavelets tangentially in the forward direction at any instant gives the new wavefront at that instant. This is called secondary wavefront.



Let us consider a diverging wave and let $F_1 F_2$ represent a portion of spherical wavefront at t = 0. According to Hugygens' principle each point of the wavefront is the source of a secondary disturbance and each point on this wavefront emits waves which travel in the medium with the same speed as that of primary wavelets. To construct new wavefronts draw spheres with each point on $F_1 F_2$ as centre and vt as radius. v is speed of light in the medium. If we draw a common envelope touching all these spheres, that will be the new wavefront. $G_1 G_2$ is the new wavefront. In a similar manner new wavefronts can be constructed for a plane wavefront also.

Figure of plane wave propagation: Refer revision page 45

(ii)



PP′ is the surface separating medium 1 and medium 2. Let v_1 and v_2 represent speed of light in these media. AB is a plane wavefront falling obliquely. By the time the wave from B reaches C, the wave from A would have travelled a distance in the second medium after refraction. If t is the time taken by the ray to travel, then BC = v_1t and the ray would travel a distance = v_2t in the second medium in the same time.

To determine the shape of the refracted wavefront, draw a sphere of radius v_2t with the point A as centre. Let CE is the tangent drawn from the point C to this sphere. Then AE = v_2t. CE would represent the refracted wavefront. Consider the △s ABC and AEC,

$$\sin i = \frac{BC}{AC} = \frac{v_1 t}{AC}; \qquad \sin r = \frac{AE}{AC} = \frac{v_2 t}{AC}$$

where i and r are angles of incidence and refraction respectively.

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \text{a constant} = n_{21}. \text{ If } r < i,\ v_2 < v_1$$

If c represents the speed of light in vacuum, then

$$n_1 = \frac{c}{v_1};\ \text{and } n_2 = \frac{c}{v_2},\ \frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$

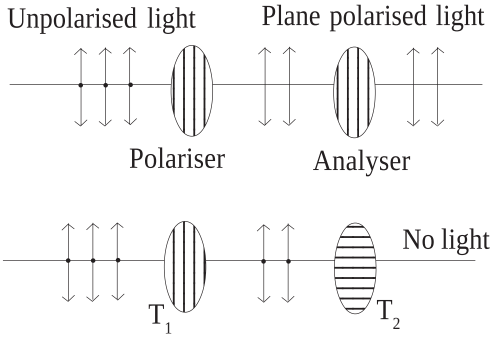
$n_1 \sin i = n_2 \sin r$

This is Snell's law of refraction.

OR

(a) The phenomenon of restricting the vibrations of light (electric vector) in a particular direction perpendicular to the direction of wave motion is called polarisation of light.

Polarization is possible only with transverse waves and not with longitudinal waves.

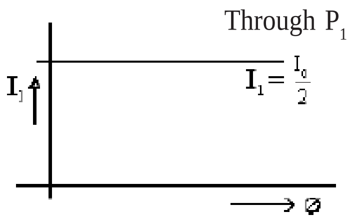


T_1 and T_2 are two thin plates of tourmaline cut with their faces parallel to the axis of the crystal. When unpolarised light falls on T_1, it allows only those vibrations which are parellel to its axis. Therefore plane polarised light comes out of T_1. When T_2 is placed with its axis parallel to T_1, light is allowed. When the crystals are in crossed position no light is allowed.

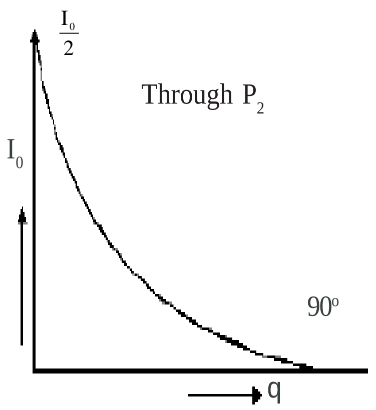
When T_2 is rotated with respect to T_1 the intensity of light varies. Maximum intensity occurs when T_1 and T_2 are parallel and zero intensity when they are in crossed positions. This observation can be explained only when we assume light waves are transverse.

Incident intensity = I_0

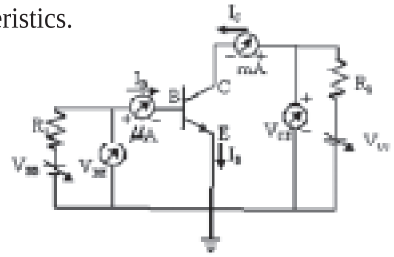
The light passing through P_1 remains constant i.e. $\frac{I_0}{2}$.



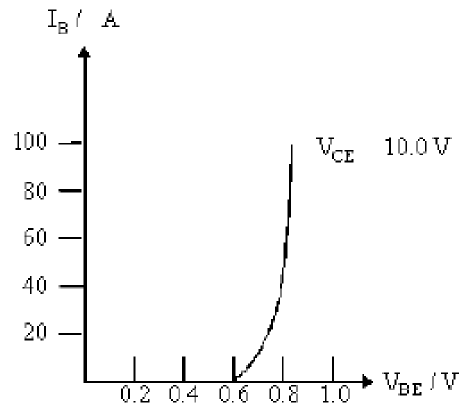
The light passing through P_2 varies with q as per the relation, $I_2 = I_1 \cos^2 q$. The light coming from a clear portion of the sky is nothing but sunlight that has changed its direction due to scattering by molecules in the earth's atmosphere. This scattered light is polarised. It, therefore, shows a variation in intensity when viewed through a polaroid on rotation.



30. Circuit diagram for drawing the input and output characteristics.



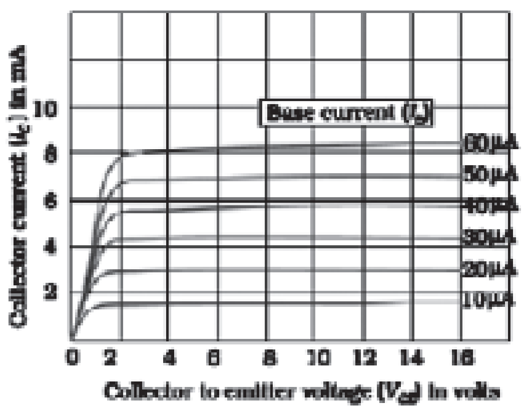
Typical shape of the input characteristics.



Cut off Stage : When the input voltage is less than a minimum value (0.6V for Si), there is no current flow in the input or output sides of the transistor. The transistor is then said to be in its 'cut-off' stage.

Active Stage : This is the stage of the transistor when the input is greater than about 0.6 V and there is some current in the output path.

Saturation stage : With increase in the input voltage beyond a certain value, the output voltage decreases and becomes almost constant at a near to zero value. The transistor is then said to be in the saturation state.



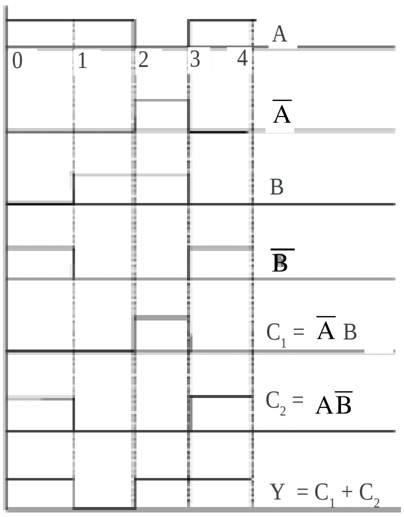
The Transistor does not remain in the active stage when it is being used as a switch.

OR

The output C_1 is the output of an AND gate having $\overline{A}$ and B as its two inputs.

The output C_2 is the output of an AND gate having A and $\overline{B}$ as its two inputs.

The output Y is the output of an OR gate having C_1 and C_2 as its two inputs. Using the truth tables for AND and OR gates, we can or therefore get the wave forms shown for C_1, C_2 and Y.

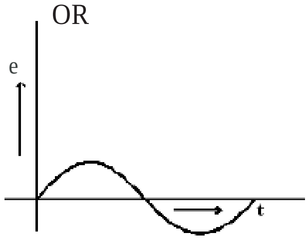


Looking at the shapes of A, B and Y, we can say that : (1) The output Y is low when both A and B are high. (2) The output Y is high when one of the input signals is high while the other is low.

SET II

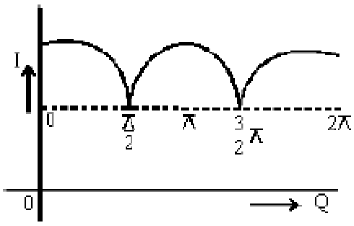
1. 180° or antiparallel
2. Nearly Zero or Zero
3. Sinusoidal Variation

OR



4. (i) Maximum - g-rays
   (ii) Minimum - Radiowaves

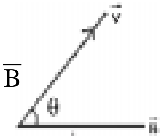
5.



6. (1, 3), (2, 4)
7. The daughter element (release of energy is accompanied by an increase of B.E)
8. (i) 'Depletion layer' width decreases.
   (ii) Junction field becomes very high
9. (i) Potential is same (= zero) in both cases
   (ii) Electric field is different in the two cases.
10. For higher values of current, we observe that the current value for a given voltage is less than given by Ohm's law. This means that R has increased for higher values of current. The increase of R is because of the increase in temperature of the resistor at higher values of the current.
11. $\vec{E} \perp \vec{v}$, $\vec{E} \perp \vec{B}$

    $\vec{v}$ is not parallel or antiparallel to $\vec{B}$

    $|\vec{E}| = vB \sin\theta$



12. $L_1 = \mu_0 n_1^2 \frac{2}{\sqrt{1}} A_1 l$, $L_2 = \mu_0 n_2^2 A_2 l$

$$M = m_0 n_1 n_2 \, p r_2^2 l, \quad \frac{M}{\sqrt{L_1 L_2}} = \sqrt{A_2/A_1} = \frac{r_2}{r_1} < 1$$

13. (i) $E = -\frac{dV}{dr} = \frac{10V}{(10^{-2})m} = 1000 \text{ Vm}^{-1}$

$\therefore |E| = 1000\text{Vm}^{-1}$

Its direction is from higher potential to lower potential point, i.e. from Y to Z.

(ii) The surface of a charged metal plate is an equipotential. \ X and Y are at the same potential.

$DV = V_y - V_x = 0$

\ Work done in moving a charge in an elecrtic field = qDV

\ Work done in moving 20mC from X to Y

$= 20 \times 10^{-6} \times 0 = 0$

14. For same current value, the total impedance must remain same.

\ $wL - \frac{1}{\omega C}$ must remain same. Thus L and C must both be halved simultaneously.

OR

The glow of the bulb will decrease.
As the iron rod is inserted in the coil, its inductance increases. As inductance incresases, its reactance also increases resulting in an increase in the impedance of the circuit.
As a result, the current in the circuit and hence the glow of the bulb will decrease.

15. (i) X-rays are e.m. waves
(ii) X-rays are transverse in nature

16. $\angle i + \angle e - \angle\delta = \angle A$
For minimum deviation $\angle i = \angle e$

$$\angle i = \frac{\angle a + \angle\delta m}{2}$$

For minimum deviation, we also have

$$\angle r = \angle r' = \frac{\angle A}{2}$$

$$\therefore \mu = \frac{\sin i}{\sin r} = \frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

17. Reduction factor = $\frac{1}{16} = \frac{1}{2^4}$ in 4 days.
Hence Half life = 1 day
For 6 days reduction factor would be $\frac{1}{2^6} = \frac{1}{64}$
Original amount = $4 \times 10^{-3} \times 64$kg = 0.256 kg

18. Point to Point : Communication over a link between a single transmitter and receiver.
Example : Telephone
Broadcast mode : Large number of receivers linked to a single transmitter.
Example : Radio

19. The two amplitudes are $\sqrt{I}$ and $\sqrt{I+\delta I}$
$\therefore$ Intensity at minima

$$\left(\sqrt{I+\delta I}-\sqrt{I}\right)^2 = I+\delta I+I-2\sqrt{I^2+\delta I.I}$$

$$= (\delta I)^2/4I$$

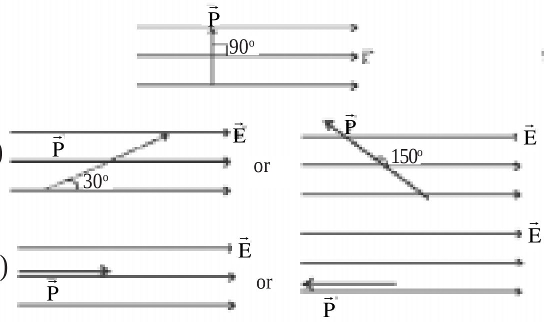
and intensity at maxima = $\left(\sqrt{I+\delta I}+\sqrt{I}\right)^2$

$$= I+\delta I+I+2\sqrt{I^2+\delta I.I} = 4I$$

20. $\vec{\tau} = \vec{p}\times\vec{E}$

Two Pairs : $\vec{\tau}$ and $\vec{p}$, $\vec{\tau}$ and $\vec{E}$

(i)
(ii)
(iii)



OR

$$V = \frac{Q}{C_1+C_2} = \frac{C_1V_1+C_2V_2}{C_1+C_2}$$

Charges = $Q_1 = C_1V$, $Q_2 = C_2V$

Energy stored = $\frac{1}{2}(C_1+C_2)V^2$

$$\frac{1}{2}\frac{(C_1V_1+C_2V_2)^2}{C_1+C_2}$$

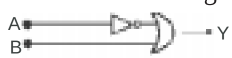
Change in energy stored = ΔU

$$= \frac{1}{2}\left[\frac{\left(C_1V_1+C_2V_2\right)^2}{C_1+C_2} - \left(C_1V_1^2+C_2V_2^2\right)\right]$$

$$= -\frac{1}{2}\frac{C_1C_2}{C_1+C_2}(V_1-V_2)^2$$

21. Output not symmetric for A, B = (0, 1) and (1,0) NOT gate in one input.
(i) has three zeros NOR gate
Thus

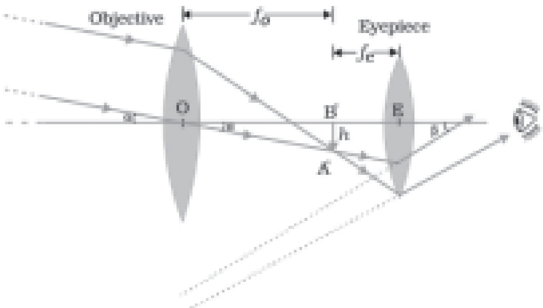
(ii) has three one's $\Rightarrow$ OR gate
Thus



22. The two main considerations
(i) Large light gathering power
(ii) Higher resolution (resolving power)
[Both these requirements are met better when an objective of large focal length as well as large aperture is used]
In an astronomical telescope, an objective O of large focal length and large aperture is used. It

forms the image of the distant object at the focal plane of the lens.

In normal adjustment of the telescope the eye piece is placed in such a way that the final image is formed at infinity.



$m = -\frac{f_0}{f_e}$ f_0 - focal length of objective

f_e - focal length of eyepiece.

Eyepiece can be placed in such a way that final image is formed at least distance of distinct vision.

Magnification produed $m = -\frac{f_0}{f_e}\left(1+\frac{f_e}{D}\right)$

Length of the telescope tube = $f_0 + f_e$

23. $\lambda = \frac{h}{p} = \frac{h}{mv}$

$\therefore\ \lambda_e = \frac{6.6\times10^{-34}}{9\times10^{-31}\times3\times10^{6}} = 2.44 \times 10^{-10}$ m

$\lambda_{ball} = \frac{6.6\times10^{-34}}{3\times10^{-2}\times100} = 2.2 \times 10^{-34}$ m

$\lambda_e \simeq$ size of atom, λ_{ball} << size of ball.

24. $q = CV = CEd = \frac{\epsilon_0 A}{d} Ed = \epsilon_0 AE$

$= \epsilon_0 \phi_E \ (\because \phi_E = EA) \quad \therefore \frac{dq}{dt} = \epsilon_0 \frac{d\phi_E}{dt}$

The term $\epsilon_0 \frac{d\phi_E}{dt}$ is known as displacement current.

This term has been used to modify and generalize Ampere's Circuital law.

25. $\bar{\upsilon} = \frac{1}{\lambda} = R\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right)$

$\therefore \lambda = \frac{\frac{1}{R}}{\left(1/n_2^2 - 1/n_1^2\right)} = \frac{970\ \mathring{A}}{\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right)}$

Let us take $n_2 = 1$ (Lyman series of hydrogen spectrum)

Here can take values

$\frac{970\ \mathring{A}}{(3/4)}, \frac{970\ \mathring{A}}{(8/9)}, \frac{970\ \mathring{A}}{(15/16)} - - - - - \frac{970\ \mathring{A}}{1}$

(Corresponding to n_1 = 2, 3, 4, -------------- ∞)

∴ Permitted values of λ are 1293.3Å, 1091Å, 1034.6 Å, --------- 970Å

Let us next take $n_2 = 2$ (Balmer series of hydrogen spectrum)

Here λ can take values

$\frac{970\ \mathring{A}}{5/36}, \frac{970\ \mathring{A}}{3/16}, \frac{970\ \mathring{A}}{21/100} - - - \frac{970\ \mathring{A}}{1/4}$

(Coresponding to n1 = 3, 4, 5----------- ∞)

Possible values of λ are 6984Å, 5173. 3Å, 4619Å, -------3880Å

Hence λ = 824Å, 1120Å, 2504Å, 6100Å, of the given lines, cannot belong to the hydrogen atom spectrum.

26. Space wave : A space wave travels in a straight line from the transmitting antenna to the receiving antenna:

Two ways : Line of sight communication and satellite communication

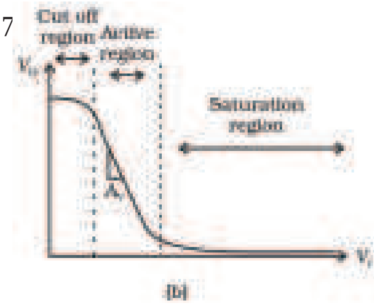
We have $D = \sqrt{2Rh_1} + \sqrt{2Rh_2}$

Let $h_1 = x$ so that $h_2 = (h - x)$

$\therefore D = \sqrt{2Rx} + \sqrt{2R(h-x)}$

$\frac{dD}{dx} = \sqrt{\frac{R}{2x}} - \sqrt{\frac{R}{2(h-x)}} = 0 \Rightarrow x = h/2$

27



Transfer characteristics of a base biased transistor in its common emiter configuration:

When V_i > 0.7V, the transistor is in active state. There will be some current I_c. From eqn. $V_0 = V_{cc} - I_cR_c$, value of output voltage V_0 decreases as the term I_cR_c increases. With the increase of V_i, I_c increases almost linearly and so V_0 decreases linearly till V_i is less than about 1V.

Beyond this the transistor goes to saturation level. We operate the transistor in the active region for using it as an 'amplifier'

28. Total resistance in the five cases are :

$$\left| r,\ r + R_1;\ r + R_2;\ r + R_1 + R_2;\ r + \frac{R_1R_2}{R_1 + R_2} \right|$$

or $r,\ r + \left[\frac{R_1R_2}{R_1 + R_2}\right]$, $r + R_1$, $r + R_2$, $r + R_1 + R_2$ in increasing order

$\therefore$ The correct order of values of I are : 4.2A, 1.4A, 1.05 A, 0.6 A and 0.42 A

Also $\frac{E}{r} = 4.2$, $\frac{E}{r + R_1} = 1.05$

$\frac{E}{r + R_2} = 0.6$, $\frac{E}{r + R_1 + R_2} = 0.42$

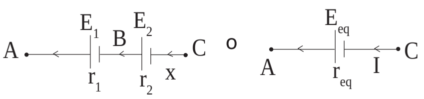
and $r + \frac{E}{\frac{R_1R_2}{R_1 + R_2}} = 1.4$

Solve first four to obtain, E = 4.2V, r = 1Ω ,

R_1 = 3Ω , R_2 = 6Ω

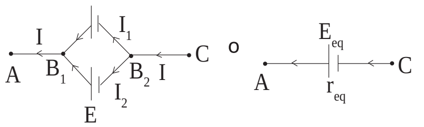
OR

(i) (a) In series



$E = E_1 + E_2$, $r = r_1 + r_2$

(ii) In parallel combination



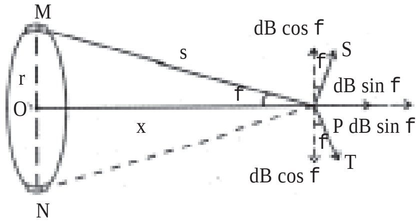
$E = \frac{E_1r_2 + E_2r_1}{(r_1 + r_2)}$, $R = \frac{r_1 r_{21}}{r_1 + r_2}$

(iii) Numerical

$$\left[\frac{2+1}{1+2+R} = \frac{(1\times2+2\times1)/(1+2)}{\frac{1\times2}{1+2}} \quad \Rightarrow R = \frac{9}{4}\Omega;\right]$$

More heat is generated in series.

29. (i)



According to Biot Savart law

$$dB = \frac{\mu_0}{4\pi}\frac{Idl\sin\theta}{s^2};$$

$$B = \oint dB\ \sin\phi = \oint \frac{\mu_0}{4\pi} \times \frac{Idl\sin\phi}{s^2}$$

$$B = \frac{\mu_0}{4\pi}\frac{I}{s^2}\sin\phi\oint dl$$

But from the symmetry of figure,

$$\sin\phi = \frac{r}{\sqrt{r^2 + x^2}} \text{ and } \oint dl = 2\pi r$$

$$B = \frac{\mu_0}{4\pi}\frac{I}{(r^2 + x^2)}\frac{r}{(r^2 + x^2)^{1/2}}2\pi r \quad (\because s^2 = r^2 + x^2)$$

The magnetic field due to a circular coil of radius r carrying a current I on a point P at an axial distance x from the centre is $B = \frac{\mu_0 IR^2 \times n}{2(x^2 + R^2)^{3/2}}$ where n is the number of turns.

(ii) Numerical

$$\left[\begin{aligned} \text{We have: } B &= \frac{\mu_0 I(3\times10^{-2})}{\left[(3\times10^{-2})^2 + (4\times10^{-2})^2\right]^{3/2}} \\ &= \frac{\mu_0 I_2(4\times10^{-2})^2}{\left[(4\times10^{-2})^2 + (3\times10^{-2})^2\right]^{3/2}} \end{aligned}\right]$$

Thus $I_2 = -\frac{9}{6}A$

Current is in opposite sense to that in L_1.

OR

(i) For current carrying circular loop, $\vec{m} = NI\vec{A}$, where $\vec{m}$ is the magnetic moment of the coil, I is the current.

N is the number of closely wound turns in the circular loop.A is the area vector of the loop

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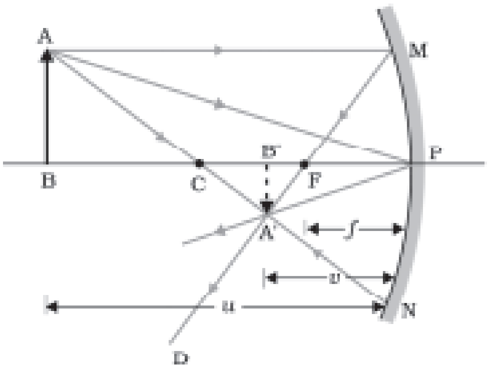
An electron moving around the central nucleus has a magnetic moment μ_l given by

$\mu_l = \frac{e}{2m} l$. Where l is the magnitude of the angular momentum of the circulating electron about the central nucleus. The smallest value of μ_l is called the Bohr magnetron. $\mu_B = 9.27 \times 10^{-24}$ J/T.

(ii) $\left[\bar{\mu} = \frac{eh}{4\pi m}\right] = 4.63 \times 10^{-26}$ A.m^2

30. (i)



The concave mirror forms a real inverted image of the object between focus and centre of curvature

Right angled triangles A'B'F and MPF are similar.

$\therefore \quad \frac{B'A'}{PM} = \frac{B'F}{FD}$ or $\frac{B'A'}{BA} = \frac{B'F}{FD}$ -------- (1)

Right angled triangles A'B'P and ABP are similar.

$\therefore \quad \frac{B'A'}{BA} = \frac{B'P}{BP}$ ------- (2) Comparing (1) and (2)

$\frac{B'F}{FP} = \frac{B'P}{BP}$ --------- (3); $\frac{B'P - FP}{FP} = \frac{B'P}{BP}$ ----- (4)

We have BP = u object distance

B'P = v image distance, FP = f focal length

Substituting in (4), $\frac{v - f}{f} = \frac{v}{u}$

uv – uf = vf, Dividing by uvf,

$\frac{1}{f} - \frac{1}{v} = \frac{1}{u}$ ie, $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

Applying sign convention

$\frac{1}{-u} + \frac{1}{-v} = \frac{1}{-f}$ ie, $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

Thin lens formula $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

(ii) Numerical $\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow v = +30$ cm

Distance of this image from the mirror must be 20 cm [μ For image to from at O, mirror must reverse the light $\therefore$ d = (30 + 20) cm = 50 cm) The final image is inverted.

OR

(i)

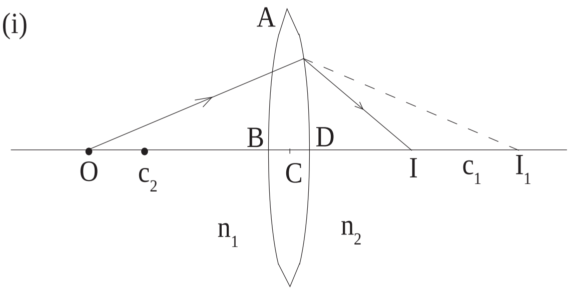


Image formation by a lens is due to refraction at two surfaces ABC and then ADC. ABC forms the virtual image of object at I_1 and it acts as the object for surface ADC. Refraction at ADC results in the formation of real image I.

For refraction at ABC

$$-\frac{n_1}{OB} + \frac{n_2}{BI_1} = \frac{n_2 - n_1}{BC_1} \text{ -------- (1)}$$

For refraction at ADC,

$$-\frac{n_2}{DI_1} + \frac{n_1}{DI} = \frac{n_1 - n_2}{DC_2} \text{ -------- (2)}$$

Since lens is assumed to be very thin distances measured from B and D are same as measured from opticcentre

$BI_1 = DI_1$. Adding 1 & 2

$$-\frac{n_1}{OB} + \frac{n_1}{DI} = (n_2 - n_1)\left(\frac{1}{BC_1} - \frac{1}{DC_2}\right) \text{ ------ (3)}$$

When OB = ∞, DI = f

$$\frac{n_1}{f} = (n_2 - n_1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \text{ ------ (4)}$$

$$\frac{1}{f} = \frac{n_2 - n_1}{n_1}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (n_{21} - 1)\left(\frac{1}{R_1} - \frac{1}{R}\right) \text{------- (5)}$$

This is lens maker's formula.

(ii) Numerical

[v = 15 cm, f = 10 cm ⇒ u = –30 cm

Distance of O from mirror: 20 cm

But O must be at radius of curvature for rays to reverse ⇒ R = 20 cm

SET III

1. E = Energy stored = $\frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$

   (The graph is showing $E \propto \frac{1}{C}$),

   Hence Q the charge on capacitors is kept constant.

2. $\frac{mv^2}{r} = Bqv$, or $r = \frac{mv}{Bq} = \frac{p}{Bq}$

   ∴ $r : r = q_p : q_a = 1 : 2$

3. The frequency of the microwaves should match the resonant frequency of the water molecules in the food.

4. 'X' is a pure capacitor ; Impedance = $\frac{1}{\omega C}$

5. $\frac{1}{f} = \left(\frac{\mu_1}{\mu_2} - 1\right)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$, the lens would now behave like a diverging (concave) lens.

6. $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mk}}$ ∴ The proton will have a higher K.E. (mass of proton is slightly less than that of the neutron).

7. The ionisation energy of silicon gets (considerably) reduced compared to that of carbon. Silicon (a semi-conductor), therefore, becomes a (much) better conductor of electricity than carbon (an insulator).

8. (0 to t_1), (t_3 to t_4).

9. (i) q_1 is a negative charge and q_2 is a positive charge.

   (ii) $V = \frac{1}{4\pi\epsilon_0}\frac{q}{r} = \frac{q}{4\pi\epsilon_0}\cdot\frac{1}{r}$

   ∴ Slope of the V versus graph is $\frac{q}{4\pi\epsilon_0}$

   Since the slope of the graph for q_1 has a larger magnitude, q_1 has the larger magnitude of the two.

10. $R_T = R_0 [1 + \alpha (T - T_0)]$

    ∴ $\frac{120}{100} = \frac{6}{5} = 1 + \alpha\ (T - T_0)$

    ∴ $T \times 10^{-4} (T - 300) = \frac{1}{5}$; T = 1300 K

11. $B = \frac{\mu I a^2}{2(a^2 + x^2)^{3/2}} = \frac{\mu_0 I}{2a(1 + x^2/a^2)^{3/2}}$

    ∴ $B = B_0\ (1 + x^2/a^2)^{-3/2}\ \left(\because B_0 = \frac{\mu_0 I}{2a}\right)$

    ∴ $B\ \ (\text{at } x = a) = B_0(2)^{-3/2} = \frac{B_0\sqrt{2}}{4} = 0.25\sqrt{2}B_0$

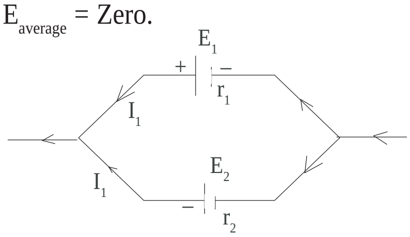
    and B (at x = 2a) = $B_0(5)^{-3/2} = \frac{B_0\sqrt{5}}{25} = 0.04\sqrt{5}B_0$

    Thus the given values are in good agreement with the theoretically expected values.

12. $E_{max} = NBA\omega = NBA\ 2\pi u$

    $= 20 \times 0.5 \times 0.09 \times 2\pi \times \frac{150}{\pi}$ volt = 270V

    $E_{average}$ = Zero.

13. 

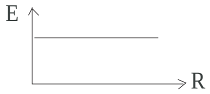
    $I = I_1 + I_2 = \frac{E_1 - V}{r_1} + \frac{E_2 - V}{r_2} = \left(\frac{E_1}{r_1} + \frac{E_2}{r_2}\right) - V\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$

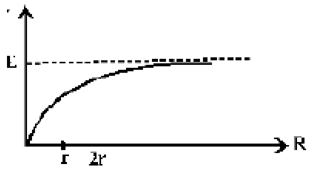
    ∴ $V = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2} - I\left(\frac{r_1 r_2}{r_1 + r_2}\right)$

    Comparing with $V = E_{eq} - Ir_{eq}$

    We get $E_{eq} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$

(i) OR





$$V = E - ir = E\Big/\left(1+\frac{r}{R}\right)$$

14. (i) The glow gradually increases till it becomes maximum
Reasons : There is a back (induced) emf in the inductor $\left(=-L\frac{di}{dt}\right)$ when the current is growing and this delays the growth of current to its final steady value.
(ii) The glow will decrease.
Reasons : The impedance of circuit will increase due to the presence of the inductive reactance of the circuit.

15. (i) UV rays (ii) (UHF) radio waves (iii) Infrared waves. $\lambda_3 > \lambda_3 > \lambda_1$

16. During the formation of pn junction two processes occur 1) diffusion 2) drift.
Due to difference in the concentration of charge carriers in two regions of p-n junction, the electrons from n- region diffuse through the junction into p-region and holes from p- region diffuse into n- region.
When electron diffuses from n- region to p- region of p-n junction, it leaves behind an ionised donor atom in n- region, having positive charge which is immobile as it is bound to the surrounding atom. As diffusion continues more positively charged donor atoms are created in n- region and it acquires positive charge at the junction.
When holes diffuse from p- region to n-region it leaves ionised acceptor atoms in p-region having negative charge. This results in the formation of a layer of negative charge at the p- region. Accumulation of charges on p side and n side produces an electric field across the junction. The electric field sets a potential barrier at the junction which opposes further diffusion of majority charges. The potential barrier will behave as if an imaginary battery is connected with positive pole to n section and negative pole to p section.

17. Modulation is the process in which a low audio frequency base band message is superimposed on a high frequency wave called carrier wave. Modulation is necessary because of the following reasons.

1. Size of antenna or aerial:- Antenna is needed both for transmission and reception. Antenna should have a minimum height of $\frac{\lambda}{4}$, so that time variation of the signal is properly sensed by the antenna. Audio frequency range is 20 Hz to 20 kHz. For an audio signal of 15kHz frequency,
$\lambda = \frac{c}{\upsilon} = \frac{3\times10^8}{15\times10^3} = 20000$ m The required length of the antenna is $\frac{20000}{4} = 5000$m.
It is difficult to construct and operate such a tall antenna. By modulation if transmission frequency is raised to 1MHz, then, $\lambda = \frac{3\times10^8}{10^6} = 300$ m. Length of the antenna is $\frac{300}{4} = 75$m, a reasonable height.
Hence it is necessary to do modulation.

2) Effective power radiated by antenna: Power radiated by an antenna $P \propto \frac{1}{l^2}$
For good transmission l should be small. For smaller antenna length, λ should be small or frequency should be high.

18. Angular width $\theta = \frac{\lambda}{a} = \frac{550\times10^{-9}}{1\times10^{-4}}$ radians
$= 5.5 \times 10^{-3}$ radians
Linear width = $D\theta$
$= 1.1 \times 5.5 \times 10^{-3}$ m = 6.05 mm
The angular width would not change.

19. $\frac{x}{y} = \frac{60}{40} = \frac{3}{2}$ and $\frac{x}{y+15} = \frac{60-10}{40+10} = 1$

solving, we get , x = 45Ω, y = 30Ω

For the parallel connection

$$Y' = \frac{30y}{30+y} = \frac{30\times 30}{30+30}\Omega = 15\Omega$$

$$\therefore \frac{x}{y'} = \frac{l}{100-l}, \quad \frac{45}{15} = \frac{l}{100-l} \Rightarrow l = 75.0 \text{ cm}$$

OR

The emf of a cell equals the p.d. between its terminals when it is in an open circuit i.e. not supplying any current. A voltmeter measures p.d. (and not emf.) as it draws a (small) current for its working. The potentiometer draws no (net) current (form the cell) at the balance point. So the cell can be treated as if it were in an open circuit.

$E_1 + E_2 = k\,(351)$ and $E_1 - E_2 = k\,(70.2)$

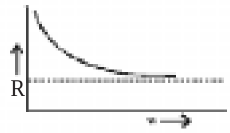
$$\therefore \frac{E_1+E_2}{E_1-E_2} = \frac{351}{70.2} = \frac{5}{1}, \text{ This gives } \frac{E_1}{E_2} = \frac{2}{3}$$

20. X → a resistor , Y → A capacitor

$$\frac{V}{R} = \sqrt{2} \text{ and } R = X_c$$

$$\therefore I = \frac{V}{2} = \frac{V}{\sqrt{R^2 + X_c^2}} = \frac{V}{R\sqrt{2}}, \quad I = \frac{\sqrt{2}}{\sqrt{2}} = 1.0\text{A}$$

(iii) X → Net Impedance



21. (a) Because such telescopes

(i) have high resolving power

(ii) produce brighter images

(b) Two identical but independent light sources cannot produce light waves continuously either in the same phase or having a constant phase difference between them. (c) Brewster angle (i_p) is given by $\tan i_p = \mu$

μ depends upon the wavelength (λ) of the incident light. Hence i_p will be different for different colours of light.

22. Work functions (i)For $M_1 = h\upsilon_{01}$

For $M_2 = h\upsilon_{02}$

(ii) For M_1, $h\upsilon_3 = h\upsilon_{01} + eV_1$ $\therefore V_1 = \frac{h}{e}\upsilon_3 - \frac{h\upsilon_{01}}{e}$

Similarly, For M_2, $V_2 = \frac{h}{e}\upsilon_3 - \frac{h\upsilon_{02}}{e}$

$$\therefore V_1 - V_2 = \frac{h}{e}(\upsilon_{02} - \upsilon_{01})$$

$$\therefore \text{Slope of either line} = \frac{h}{e} = \frac{V_1 - V_2}{\upsilon_{02} - \upsilon_{01}}$$

23. Continuous locus of all the particles of a medium which are vibrating in the same phase is called a wavefront.

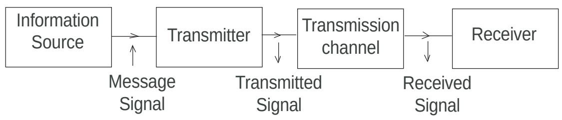
Refer set 1, page 153 answer 29 (first part)

24. The activity of a radioactive element at any instant, equals its rate of decay at that instant. Its SI unit is Becquerel (Bq) (= 1 decay per second)

$$\text{Activity } R = -\frac{dN}{dt} = \lambda N = \frac{\log_e 2}{T} N$$

$$\therefore \frac{R_1}{R_2} = \frac{N_1}{T_1} \div \frac{N_2}{T_2} = \frac{N_1 T_2}{N_2 T_1}$$

25. (i)



(ii) Detection is the process of recovering the modulating (or information) signal from the modulated carrier wave. The essential steps followed in the process of detection are (i) The AM input wave is passed through a rectifier to obtain its rectified waveform. (ii) The rectified wave is passed through an 'envelope detector' which retrieves the message signal as the envelope of the rectified wave.

26. (i) n - p -n transistor. (ii) Common emitter

(iii) Considering characterstics for

I_b = 10μA and I_b = 50μA

$$B = \left(\frac{\Delta I_c}{\Delta I_b}\right) = \frac{(8.5-2.5)\times 10^{-3}}{(50-10)\times 10^{-6}} = 150$$

27. The permitted stationary orbits for the electron in a hydrogen atom are those for which the angular momentum of the electron is an integral multiple of h/2π $mv_n r_n = n\frac{h}{2\pi}$ $\therefore 2\pi r_n = n\frac{h}{mv}$

But $\frac{h}{mv_n} = \lambda_n$ the associated de Broglie wavelength

for electron in its nth orbit
Hence $2\pi r_n = n\lambda_n$
or circumference of n^{th} permitted orbit
= n × de Broglie wavelength
associated with the electron in the n^{th} orbit.

28. Capacitance of a capacitor is the ratio of charge given to the p. d between the plates. $C = \frac{Q}{V}$. Its unit is farad.
Capacitance of a parallel plate capacitor is $C = \frac{\varepsilon_0 A}{d}$, where A is the area of the plates and d is the separation between the plates.

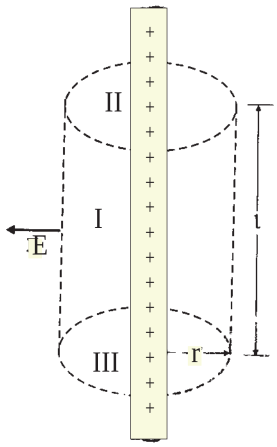
(ii) Net capacitance = 4mF

Energy stored (W) = $\frac{1}{2}CV^2 = 0.02$ J

Charge q = CV = 4×10^{-4} coulomb

OR

(a) Consider a long straight wire carrying a charge q. Let λ be its linear charge density. Hence $Q = \lambda l$. Let us consider a Gaussian cylinder as shown in figure.



In regions II and III

$\phi_{II} = \phi_{III} = \int E.ds\cos\theta$

$= 0 \left[\because \vec{E} \perp \vec{ds}, \text{ie}, \theta = 90\right]$

The flux through the curved surface [region I]

$\phi_I = \int E.ds\cos\theta$

$= \int E.ds \quad (\theta = 0) = E.2\pi rl \quad [\because \int ds = 2\pi rl]$

The total flux through the Gaussian cylinder

$\phi = \phi_I + \phi_{II} + \phi_{III} = E.2\pi rl$ ---(1)

According to Gauss's theorem flux $\phi = \frac{Q}{\varepsilon_0} = \frac{\lambda l}{\varepsilon_0}$ ---- (2)

Comparing (1) & (2); $E.2\pi rl = \frac{\lambda l}{\varepsilon_0}$

$E = \frac{\lambda l}{2\pi\varepsilon_0 r}$, radially outward.

(b) (i) E = 5Ax + 2 B = 50 x + 10

Electric flux through the face with point M on it

$\phi_1 \cong E.ds = E\,ds\cos 180^o$

$\phi_1 = -E_1 ds = -(0 + 10) \times 0.01 = -0.1\ NC^{-1}\ m^2$

Similarly, flux through the face having point 'N' on it

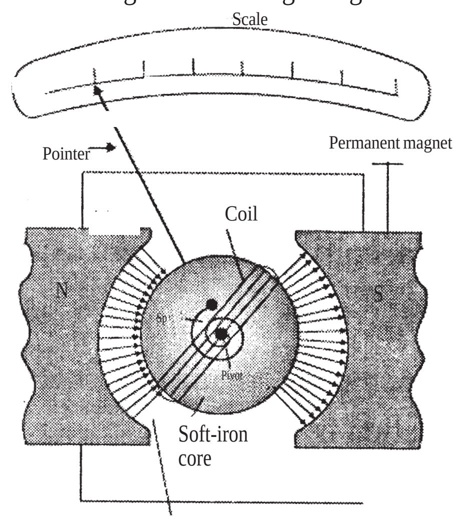
$\phi_2 = -E_2 ds\cos 0^0 = (50 \times 0.1 + 10) \times 0.01$
$= 0.15\ NC^{-1}m^2$

(Flux through all other faces will be Zero)

∴ Total flux through the cube = $\phi_1 + \phi_2$
$= -0.1 + 0.15 = 0.05NC^{-1}\ m^2$

(ii) $\phi = \frac{q}{\epsilon_0}$ ∴ $q = \epsilon_0\,\phi = 44.25 \times 10^{-14}$ C

29. (a) Labelled diagram of moving coil galvanometer



Deflecting torque on the coil = NI BA sinθ
In radial magnetic field $\theta = 90^o$
∴ Deflecting torque = NIA B
Counter torque provided by the spring = Kϕ

∴ In equilibrium Kϕ =NIAB ∴ $\phi = \left(\frac{NBA}{K}\right)I$

The quantity in bracket is constant ∴ $\phi \propto I$

(b) (i) $R_1 = \frac{V}{I_g} - G \quad \therefore \frac{V}{I_g} = R_1 + G$

(ii) and $R_2 = \frac{V}{2I_g} - G \quad \therefore \frac{V}{I_g} = 2R_2 + 2G$

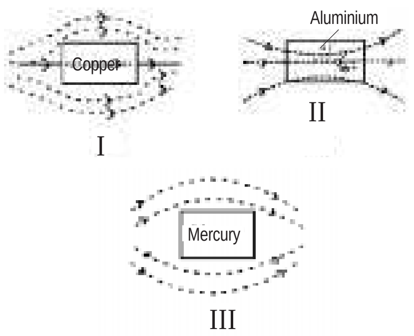
On comparison $G = R_1 - 2R_2$

$\therefore \quad R_3 = \frac{2V}{I_g} - G = 2(R_1 + G) - G = 2R_1 + G$

$= 2R_1 + R_1 - 2R_2 = 3R_1 - 2R_2$

OR

(a) We know that (i) copper is diamagnetic (ii) Aluminium is paramagnetic and (iii) mercury (cooled to 4.2 K) is perfect diamagnetic. Hence the behaviour of field lines is as shown here



(b) (i) $\tan\theta = \frac{V}{H} = \frac{\sqrt{3}H}{H} = \sqrt{3}$

$\therefore \theta = \tan^{-1}\left(\sqrt{3}\right)$ or 60^o

(ii) Horizontal Component $= B_E \cos\theta = B_E \cos 60^o$

$= 0.4 \times \sqrt{3/2} = 0.346$ G

30.(a)

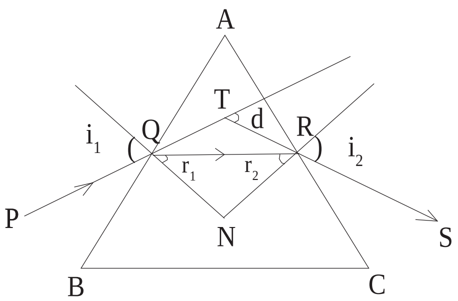


Figure shows passage of a light ray through a prism. It undergoes two refractions and finally emerges out along RS bending towards the base.

In Quadrilateral $\angle AQN + \angle ARN = 180^o$ (normals at Q and R)

$\therefore \angle A + \angle N = 180^o$ ------ (1)

In Δ QNR, $r_1 + r_2 + N = 180^o$ ------ (2)

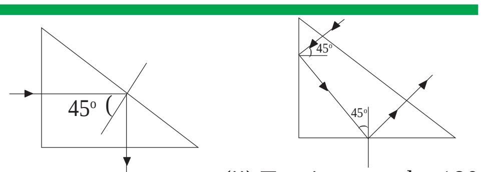
From (1) and (2)

$r_1 + r_2 = A$ ------- (3)

From ΔTQR, $d = i_i - r_1 + i_2 - r_2 = i_1 + i_2 - (r_1 + r_2)$

$d = i_1 + i_2 - A$ --------- (4)

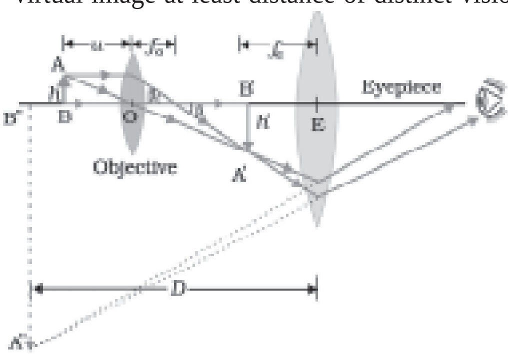
(b)



(i) Turning a ray by 90° (ii) Turning a ray by 180°

OR

(a) **Compound microscope:-** It is used for observing highly magnified images of objects. The objective lens of small focal length and short aperture forms a real, enlarged inverted image of the object. The eye of large focal length and large aperture is placed in such a way that the first image is within the focus of the eyepiece. Eyepiece forms an enlarged virtual image at least distance of distinct vision.



The magnification produced by the eyepiece is

$M_e = 1 + \frac{D}{f_e}$

$M_0 = \frac{A'B'}{AB} = \frac{v_0}{u_0}$

$M = \frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right)$

The focal length of the objective lens is very small, $u_0 = f_0$. The focal length of the eye piece is also very short. So that $v_0 = L$, where L is equal to length of the microscope tube.

$\therefore M = \frac{L}{f_0}\left(1 + \frac{d}{fe}\right)$

(b) Resolving power of microscope RP $= \frac{2\mu \sin\beta}{1.22\lambda}$

(i) Decreasing diameter of objective will decrease $\therefore$ Hence R P will decrease.

(ii) No effect