CBSE
Class XII Physics
Sample Paper 2

Time: 3 Hours **Maximum Marks: 70**

General Instructions:

1. All questions are compulsory. There are 33 questions in all.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
3. Section A contains ten very short answer questions and four assertion reasoning MCQs of 1 mark each, Section B has two case based questions of 4 marks each, Section C contains nine short answer questions of 2 marks each, Section D contains five short answer questions of 3 marks each and Section E contains three long answer questions of 5 marks each.
4. There is no overall choice. However internal choice is provided. You have to attempt only one of the choices in such questions
5. 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

$\mu_o = 4\pi \times 10^{-7}$ T m A^{-1}

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

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

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

mass of neutron = 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

Directions (Q1-Q10) Select the most appropriate option from those given below each question

1. Find the value of peak voltage in a 220-V AC source,

2. For which type of current does a capacitor behave as an infinite resistance?

OR

In which form is the energy stored in a capacitor?

3. Which among the following statements are true

A. Emf in a conductor can be induced by moving it in a magnetic field.

B. Emf in a conductor can be induced by changing the magnetic field around it.

4. A metal rod is moved with velocity 'v' in the presence of a magnetic field. Write the necessary condition for generating potential difference across the ends of the rod.

5. The threshold frequency of a metal is f_0. What is the necessary condition for photoelectric effect to occur? (Considering f = the frequency of incident light)

OR

A metal surface ejects electrons when hit by green light but nothing when hit by yellow light. Out of VIBGYOR what are the possible colors of the visible light which is responsible for ejecting electron from the metal surface

6. If the wavelength of a photon is increased, then what will be the effect on linear momentum (P) and energy (E)?

7. Which physical quantity remains constant during refraction.

OR

List down the phenomena caused due to total internal reflection of light.

8. A point object is placed at a distance of 60cm from a concave mirror having focal length 30 cm. Find the image distance.

9. What would be the electric flux through the closed surface enclosing the capacitor of capacitance C and which is charged to potential E.

10. Three capacitors of $12\mu F$ each are available. Find the minimum and maximum capacitance obtained?

OR

What is the SI unit of electric potential energy?

For question numbers 11, 12, 13 and 14, two statements are given-onelabelled Assertion (A) and the other labelled Reason (R). Select thecorrect answer to these questions from the codes (a), (b), (c) and (d)as given below.

a) Both A and R are true and R is the correct explanation of A

b) Both A and R are true but R is NOT the correct explanation of A

c) A is true but R is false

d) A is false and R is also false

11. Assertion : The induced emf and current will be same in two identical loops of copper and aluminium, when rotated with same speed in the same magnetic field.

Reason : Mutual induction does not depend on the orientation of the coils

12. Assertion : Total energy of electron in an hydrogen atom is negative.
Reason : It is bounded to the nucleus.

13. Assertion: For best contrast between maxima and minima in the interference pattern of Young's double slit experiment, the intensity of light emerging out of the two slits should be equal.
Reason: The intensity of interference pattern is proportional to square of amplitude.

14. Assertion: If three capacitors of capacitance $C_1<C_2<C_3$ are connected in parallel then their equivalent capacitance Cp>Cs

Reason : $\frac{1}{C_p}=\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}$

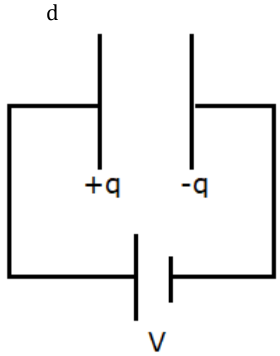
Section B

Directions (Q16 –Q20) Answer the following
Questions 15 and 16 are Case Study based questions and are compulsory. Attempt any 4 sub parts from each question. Each question carries 1 mark.

15. A capacitor is a system of two conductors separated by an insulator. Its capacitance is defined by C = q/V, where q and –q are the charges on the two conductors and V is the potential difference between them. C is determined purely geometrically, by the shapes, sizes and relative positions of the two conductors. The unit of capacitance is farad:

$1\ F = 1\ C\ V^{-1}$

$C=\frac{\varepsilon_0 A}{d}$



For a parallel plate capacitor (with vacuum between the where A is the area of each plate and d the separation between them)

a) If the medium between the plates of a capacitor is filled with an insulating substance (dielectric), having dielectric constant K, then new capacitance C′ would be

i. $C'=K^2C$

ii. $C'=\frac{C}{K^2}$

iii. $C' = \frac{C}{K}$

iv. $C' = KC$

b) If the medium between the plates of a capacitor is filled with an insulating substance (dielectric), having dielectric constant K, and the battery remains connected, what would be the value of potential difference across the capacitor

i. V

ii. V/K

iii. KV

iv. K^2V

c) If the medium between the plates of a capacitor is filled with an insulating substance (dielectric), having dielectric constant K, and the battery remains connected, what would be the value of final charge on the capacitor

i. q/K

ii. q/K^2

iii. Kq

iv. q

d) If the medium between the plates of a capacitor is filled with an insulating substance (dielectric), having dielectric constant K, and the battery remains connected, what would be the value of electric field between the plates, (initially the value of electric field is E)

i. E

ii. KE

iii. K^2E

iv. E/K

e) If the medium between the plates of a capacitor is filled with an insulating substance (dielectric), having dielectric constant K, and the battery remains connected, what would be the value of energy stored between the plates of the capacitor(initially the value of energy stored between the plates is U)

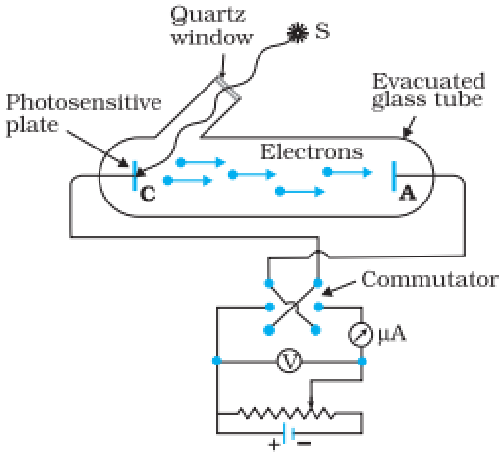
i. U/K

ii. KU

iii. K^2U

iv. U

16. The figure given below depicts a schematic view of the arrangement used for the experimental study of the photoelectric effect .The plate A can be mantained at a desired positive or negative potential with respect to emitter C. When the collector plate A is positive with respect to the emitter plate C, the electrons areattracted to it. The emission of electrons causes flow of electric current in the circuit. The potential difference between the emitter and collector plates is measured by a voltmeter (V) whereas the resulting photo current flowing in the circuit is measured by a microammeter (μA). The photoelectric current can be increased or decreased by varying the potential of collector plate A with respect to the emitter plate C. The intensity and frequency of the incident light can be varied, as can the potential difference V between the emitter C and the collector A.



Answer the following questions based on the above mention experiment of photoelectric current.

a) On keeping the frequency of the incident radiation and the potential fixed, if the intensity of incident radiation increases, the photoelectric current will
   i. Increases
   ii. Decreases
   iii. Remains constant
   iv. None of these

b) For a given frequency of the incident radiation, the stopping potential will
   i. Increases with increase in intensity'
   ii. Decreases with increase in intensity
   iii. Be independent of intensity
   iv. None of these

c) If the order of frequency of radiation is $\nu_{01} > \nu_{02} > \nu_{03}$, what would be the correct order of stopping potential
   i. $V_{01} > V_{02} > V_{03}$
   ii. $V_{01} < V_{02} < V_{03}$
   iii. $V_{01} = V_{02} = V_{03}$
   iv. None of these

d) The emission of photoelectron below the threshold frequency
   i. Increases with increase in intensity
   ii. Decreases with increase in intensity
   iii. No emission of photoelectron takes place
   iv. None of these

e) The minimum energy required to remove an electron is called
   i. Stopping potential
   ii. Kinetic energy
   iii. Work function
   iv. None of these

What is the ratio of the speed of infrared rays to ultraviolet rays in vacuum?

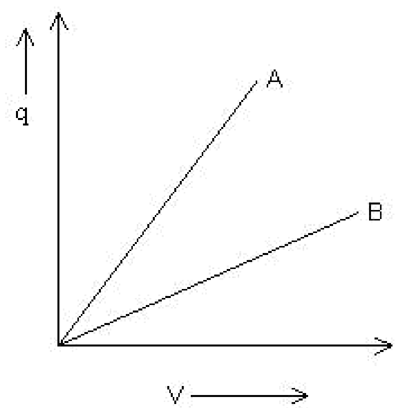
Section C

All questions are compulsory. In case of internal choices, attempt any one.

17. An electric dipole with dipole moment 4×10^{-9} C m is aligned at 30° with the direction of a uniform electric field of magnitude 5×10^{4} NC^{-1}. Calculate the magnitude of the torque acting on the dipole.

OR

The given graph shows variation of charge q versus potential difference V for capacitors C_1 and C_2. The two capacitors have same plate separation. However, the plate area of C_2 is double that of C_1. Which of the lines in the graph correspond to C_1 and C_2 and why?



18. What is the change in resistance of a wire when its radius is halved and the length is reduced to one-fourth of its original value?

19. Find the wavelength of electromagnetic waves of frequency 6×10^{12} Hz in free space. Give two applications of this wave.

20. Explain how the maximum kinetic energy of electrons emitted from a metal surface varies with the frequency of incident radiation.

OR

Draw a graph showing the variation of stopping potential with frequency of incident radiation in relation to the photoelectric effect. Deduce an expression for the slope of this graph using Einstein's photoelectric equation.

21. Why is a semiconductor damaged by a strong current?

22. What is a transducer? Give two examples.

23.

(a) State two advantages of pulse code modulation over amplitude modulation.

(b) What is the range of FM signals? Why is an FM signal less susceptible to noise than an AM signal?

OR

What is a geostationary satellite? What are the basic requirements for such a satellite?

24. Two identical loops, one of copper and the other of aluminium are rotated with the same angular speed in the same magnetic field. Compare
(i) the induced emf and
(ii) the current produced in the two coils. Justify your answer.

25. A light bulb is rated 100 W for 220 V ac supply of 50 Hz. Calculate
(i) the resistance of the bulb;
(ii) the rms current through the bulb.

Section D

All questions are compulsory. In case of internal choices, attempt any one.

26. S_1 and S_2 are two hollow concentric spheres enclosing charges Q and 2Q, respectively.
(i) What is the ratio of the electric flux through S_1 and S_2?
(ii) How will the electric flux through the sphere S_1 change if a medium of dielectric constant 5 is introduced in the space inside S_1 in place of air?

OR

Two dielectric slabs of dielectric constants K_1 and K_2 and of equal width are filled in between two plates, each of area A, of a parallel plate capacitor. How does the capacitance of the capacitor get affected?

27. What are eddy currents? How to minimizethem? Explain any two uses of eddy currents in detail.

28. How does the size of a nucleus depend on its mass number? Explain why the density of nuclear matter is independent of the size of a nucleus.

OR

Distinguish between isotopes and isobars. Give one example of each.

29. Give the frequency ranges of the following:
(i) High frequency band (HF)
(ii) Ultra high frequency band (UHF)
(iii) Super high frequency band (SHF)

30. How does conductivity change with a rise of temperature in case of semiconductors?

Section E

All questions are compulsory. In case of internal choices, attempt any one.

31. Using Ampere's circuital law, derive an expression for the magnetic field along the axis of a toroidal solenoid. (5)

OR

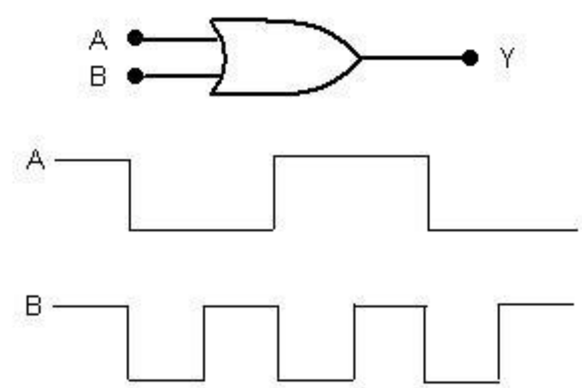
Derive an expression for the torque on a rectangular coil of area A carrying current I placed in a magnetic field B at an angle θ to the direction of the field.

32. Derive lens maker's formula for a double convex lens. (5)

OR

Plot a graph to show variation of the angle of deviation as a function of angle of incidence for light passing through a prism. Derive an expression for refractive index of the prism in terms of angle of minimum deviation and angle of prism
Find out the relation between the refractive index (μ) of the glass prism and $\angle A$ for the case when the angle of prism (A) is equal to the angle of minimum deviation (δm). Hence obtain the value of the refractive index for angle of prism A = 60°.

33. The circuit symbol of a logic gate and two input waveforms A and B are shown in the figure given below: (5)



i) Name the logic gate.
ii) Write its truth table.
iii) Tabulate the details of output waveform and represent its output waveform graphically.

OR

A transistor is used in the common emitter mode in an amplifier circuit. When a signal of 20 mV is added to the base–emitter voltage, the base current changes by 20 μA and the collector current changes by 2 mA. The load resistance is 5 $k\Omega$. Calculate (a) factor β, (b) input resistance R_{BE}, (c) transconductance and (d) voltage gain.

CBSE
Class XII – Physics
Sample Paper 2– Solution

Section A

1. Approximately 311 V

$$V_{rms} = \frac{V_{peak}}{\sqrt{2}}$$
$$V_{peak} = \sqrt{2}V_{rms}$$
$$V_{peak} = \sqrt{2} \times 220 = 311.08 \text{ V}$$

2. DC
After being fully charged, the capacitor does not allow the charge to flow through it, and hence,it acts as an infinite resistance.

OR

Electric field

3. Both A and B are true.
Emf can be induced either by moving the conductor or by changing the magnetic field or both.

4. $v \perp l \perp B$
$Emf = Blv$. Emf is not induced when the metal rod moves in the direction of the magnetic field or when the length is in the same direction of the magnetic field.

5. $f \geq f_0$.
The photoelectric effect takes place when energy of incident radiation is more than the work function of the metal.

OR

Violet, Indigo and Blue,as these colours has shorter wavelength and hence generate enough energy to eject electron.

6. Both decreases
$$p = \frac{h}{\lambda}, E = hf = \frac{hc}{\lambda}.$$

7. Frequency
During refraction frequency of the source remains constant.

OR

The brilliance of a diamond is due to total internal reflection. Optical fibre works on the principle of total internal reflection. This phenomenon is used in many optical instruments like telescopes, microscopes, binoculars, spectroscopes, periscopes etc.

8. 60 cm in front of the mirror
When the object is placed at the centre of curvature, the image is also formed at the centre of curvature.

9. Zero
Flux is given by $\phi = \frac{q}{\varepsilon_0}$.The net charge inside the closed surface is zero. Hence,the electric flux would be zero.

10. $4\mu F, 36\mu F$

Minimum capacitance

In series

$$\frac{1}{C} = \frac{1}{12} + \frac{1}{12} + \frac{1}{12}$$

$c = 4\mu F$

Mximum capacitance

In parallel

$C = 12 + 12 + 12 = 36\mu F$

OR

Joule

Section B

11. Assertion and Reason both are false.
A: The emf will be same but current will different as resistance will be different of Cu and Al.
R: Mutual inductance depends on orientation of coil, size, shape, no. of turns and relative position.

12. Both A and R are true and R is the correct explanation of A
We know that $E=-13.6/n^2$ eV
It shows that total energy of electron in a stationary orbit in a hydrogen atom is negative, which means the electron is bound to the nuclear and is not free to leave it.

13. Both A and R are true but R is NOT the correct explanation of A

When intensity of light emerging from two slits is equal, the intensity at minima,
$I_{min} = \left(\sqrt{I_a} - \sqrt{I_b}\right)^2 = 0$, or absolute dark. It provides a better contrast.

14. If both assertion and reason are true but reason is not the correct explanation of the assertion.
Equivalent capacitance of parallel combination is Cp=C1+C2+C3

15. A) iv. $C' = KC$. If the medium between the plates of a capacitor is filled with an insulating substance (dielectric), the electric field due to the charged plates induces a net dipole moment in the dielectric. This effect, called polarisation, gives rise to a field in the opposite direction. The net electric field inside the dielectric and hence the potential difference between the plates is thus reduced. Consequently, the capacitance increases from its value C when there is no medium (vacuum).
b) i. Potential difference across the plates of the capacitor would remain same.
c)iii. Final charge on the plates of the capacitor would be Kq
d)i. As E=V/d and here V and d both remains constant hence the electric field betweenthe plated would remain same as before .
e) ii. A s $U=CV^2/2$, so if capacitance becomes KC U would become KU

16. A) i. Increases
B) iii. Independent of intensity.
c) i. $V_{01} > V_{02} > V_{03}$
d)iii. No emission of photoelectron takes place
e)iii. Workfunction

Section C

17. Torque $\tau = pE\sin\theta$
$\because\ p = 4 \times 10^{-9}\,Cm,\ E = 5 \times 10^4\ NC^{-1},\ \theta = 30^\circ$
$\tau = 4 \times 10^{-9} \times 5 \times 10^4 \sin\ \theta = 30^\circ$
$\tau = 10^{-4}\,Nm$

OR

Capacitance of parallel plate capacitor $C = \frac{\varepsilon_o A}{d} \propto A$
Plate area of C_2 is double that of C_1, thus, $C_2 = 2C_1$.
Slope of *q* – *V* graph $= \frac{q}{V} = C$
As the slope of A is greater than the slope of *B*, *A* corresponds to a larger capacitance, i.e. C_2 and B to a smaller capacitance, i.e. C_1.

18. Resistance, $R = \frac{\rho\ell}{A} = \frac{\rho\ell}{\pi r^2}$

New radius $r' = r/2$
New length $\ell' = \ell/4$

$\therefore$ New resistance $R^1 = \frac{\rho\ell^1}{\pi r'^2} = \frac{\rho(\ell/4)}{\pi(r/2)^2} = \frac{\rho\ell}{\pi r^2} = R$

Resistance of the wire will remain unchanged.

19. Wavelength $\lambda = \frac{c}{\nu} = \frac{3\times10^8}{6\times10^{12}} = 5\times10^{-5}$ m

This wavelength corresponds to infrared waves.
Applications of infrared waves:
(i) They are used in greenhouses to warm plants.
(ii) They are used in taking photographs in fog.

20. According to Einstein, when a photon of incident light strikes a bound electron of metal, its energy is used in two ways:
(i) In overcoming the work function of the metal to free metallic electrons
(ii) In imparting kinetic energy to this freed electron,

i.e. $h\nu = w + E_k$

When $E_k = 0$, $\nu = \nu_0$ (threshold frequency),

$h\nu_0 = w + 0$

$w = h\nu_0$

Therefore, $h\nu = h\nu_0 + E_k$

$E_k = h(\nu - \nu_0)$

So, as the frequency of incident radiation ν increases, the maximum KE of photoelectrons alsoincreases.

OR

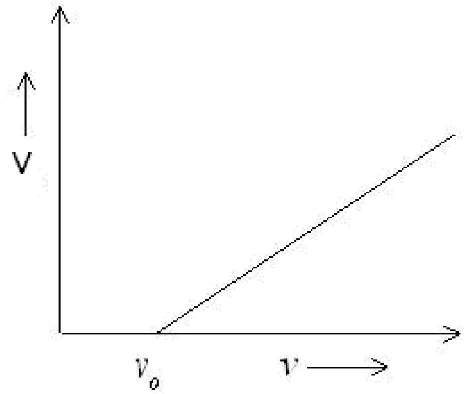
From Einstein's photoelectric equation,

$E_k = h\nu - h\nu_0$

$eV = h\nu - h\nu_0$ (V = stopping potential)

$V = \frac{h}{e}\nu - \frac{h}{e}\nu_0$

Thus, V vs ν graph is a straight line of the form $y = mx + c$ and the slope of graph is $m = \frac{h}{e}$.



21. When a strong current is passed through a semiconductor, it heats up the semiconductor. Due to which a large number of covalent bonds break up in the semiconductor. This results in a large number of charge carriers. As a result, the material starts behaving as a conductor. At this stage, the semiconductor loses the property of low conduction.

22. A transducer is a device which converts one form of energy to another. A microphone at the transmitting station and a loudspeaker at the receiving station are examples of transducers.

23.

(a) Advantages of pulse code modulation over amplitude modulation:
  (i) Free from noise and interfering signals
  (ii) Allows coded electrical signals

(b) Range of FM signals: 88–108 MHz

First, the FM signals are in the form of a frequency variation, so they do not get disturbed by the noise generated by atmospheric or man-made electrical discharge. Second, the amplitude variations due to noise in FM signals can easily be removed before demodulation.

OR

The satellite which appears to be at a fixed position at a definite height to an observer on the Earth.

Essential conditions:

(i) A geostationary satellite should be at a height of nearly 36,000 km above the equator.

(ii) Its period of revolution around the Earth should be the same as that of the Earth about its axis which is 24 hours.

(iii) It should revolve in an orbit concentric to the plane of the equator.

(iv) Its sense of rotation should be the same as that of the Earth about its own axis, i.e. from west to east. Its orbital velocity is nearly 3.1 km/s.

24. (i)The induced emf in both the loops will be same as areas of the loop and time periods are same as they are identical and rotated with same angular speed.

(ii)The current induces in Cu coil is more than Al coil as Cu coil have got lesser resistance and $I \propto \frac{1}{R}$

25. i) $P = \frac{V^2}{R} \Rightarrow R = \frac{V^2}{P} = \frac{220 \times 220}{100} = 484\Omega$

ii) $I_{rms} = \frac{V_{rms}}{R} = \frac{220}{484} = 0.45 amper$

Section D

26. (i)According to Gauss's law, electric flux through $S_1$and S_2 is given as follows

$$\phi_1 = \frac{1}{\varepsilon_0}Q$$

$$\phi_2 = \frac{1}{\varepsilon_0}(Q + 2Q) = \frac{1}{\varepsilon_0}.3Q$$

$$\frac{\phi_1}{\phi_2} = \frac{1}{3}$$

(ii) When a medium of dielectric constant K = 5 is introduced in the space inside S_1 in place of air, the flux through S_1 will be modified to

$$\phi_1' = \frac{1}{\varepsilon}Q = \frac{1}{k\varepsilon_0}Q = \frac{\phi_1}{k} = \frac{\phi_1}{5}$$

Thus, the flux will be reduced to (1/5) of its previous value.

OR

The described arrangement is equivalent to two capacitors joined in parallel where the area of the plates of either capacitor is $\frac{A}{2}$.

Thus, $C_1 = \frac{k_1\varepsilon_0(\frac{A}{2})}{d} = \frac{k_1\varepsilon_0 A}{2d}$

and $C_2 = \frac{k_2\varepsilon_0(\frac{A}{2})}{d} = \frac{k_2\varepsilon_0 A}{2d}$

Therefore, net capacitance of the capacitor

$$C = C_1 + C_2 = \frac{k_1\varepsilon_0 A}{2d} + \frac{k_2\varepsilon_0 A}{2d}$$

$$= \frac{\varepsilon_0 A}{d}(\frac{k_1 + k_2}{2})$$

27. Eddy currents are currents induced in the bulk pieces of conductors when the amount of magnetic flux linked with the conductor changes.

To minimise eddy currents:

(i) The metal core to be used in an appliance should be in the form of thin sheets. These sheets must be electrically insulated, and the planes of these sheets are arranged parallel to the magnetic field so that they cut across the eddy current paths.

(ii) Large resistance between the thin sheets confines the eddy currents to the individual sheets. Hence, the eddy currents can be reduced to a large extent.

(iii) As the dissipation of energy is directly proportional to the square of the strength of electric current, heat loss gets highly reduced.

Although eddy currents have disadvantages,they can be used in many ways.

Applications: (any two)

(i) Electromagnetic damping:

When a steady current is passed through the coil of a galvanometer, it is deflected. Hence, the coil oscillates in its mean position for some time before coming to rest. Thus, it is unable to read the galvanometer deflection.

When eddy currents flow in metallic frames, the coil comes to rest at the equilibrium position instantly. This is called electromagnetic damping.

(ii) Magnetic brakes:

In some electrically powered trains, strong electromagnets are situated in the train just above the rails. When these electromagnets are activated, eddy currents induced in the rails oppose the motion of the train.

(iii) Induction motor:

In an induction or AC motor, a rotating magnetic field produces strong eddy currents in a rotor, which starts rotating in the direction of the rotating magnetic field.

28. The radius (size) R of the nucleus is related to its mass number (A) as

$R = R_0 A^{1/3}$, where $R_0 = 1.1 \times 10^{-15}$ m

If *m* is the average mass of a nucleon, then

Mass of the nucleus = mA, where A = mass number

Volume of the nucleus $= \frac{4}{3}\pi R^3 = \frac{4}{3}\pi R_0^3 A$

$\therefore$ Density of the nucleus $\rho_N = \frac{mass}{volume} = \frac{mA}{\frac{4}{3}\pi R_0^3 A}$

$$\rho_N = \frac{3m}{4\pi R_0^3}$$

Thus, nuclear density ρ_N is independent of mass number A.

OR

The element which have same atomic number but different mass number are called isotopes Example Isotopes of carbon $6C^{10}$,$6C^{11}$,$6C^{12}$,$6C^{14}$The buclides of different element having same mass number but different atomic number are called isobarsFor example H_1^3 and He_2^3

Li_3^7 and Be_4^7

29.

(i) High frequency band: $3\,MHz - 30\,MHz$

(ii) Ultra high frequency band: $300\,MHz - 3000\,MHz$

(iii) Super high frequency band: $3000\,MHz - 30,000\,MHz$

30. Due to the electric field, both electrons and holes in a semiconductor move in the opposite direction with drift velocities v_e and v_h, respectively.
Mobility of electrons is defined as drift velocity per unit electric field.
If there is no electric field,the drift velocity becomes zero.
Thus, mobility of electrons

$$\mu_e = \frac{v_e}{E} \text{ or } v_e = \mu_e E$$

and mobility of holes is,

$$\mu_h = \frac{v_h}{E} \text{ or } v_h = \mu_h E$$

$$\text{We know, } \frac{E}{\rho} = e\left(n_e v_e + n_h v_h\right)$$

$$\therefore \frac{E}{\rho} = e\left(n_e \mu_e + n_h \mu_h\right)E$$

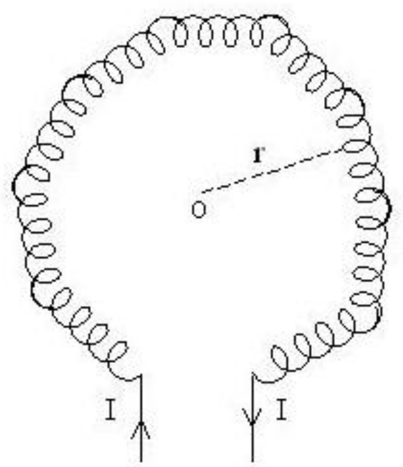
$$\therefore \frac{1}{\rho} = e\left(n_e \mu_e + n_h \mu_h\right)$$

$$\Rightarrow \text{Conductivity, } \sigma = e\left(n_e \mu_e + n_h \mu_h\right)$$

As the number of electrons n_e and the number of holes n_h increase with an increase in temperature, conductivity of the semiconductor also increases with a rise in temperature.

Section E

31. Magnetic field due to a toroidal solenoid:
A long solenoid shaped in the form of a closed ring is called a toroidalsolenoid.
Let *n* be the number of turns per unit length of the toroid and I be the current through it. The current causes the magnetic field inside the turns of the solenoid. The magnetic lines of force inside the toroid are in the form of concentric circles. By symmetry, the magnetic field has the same magnitude at each point of the circle and is along the tangent at every point on the circle.



For points inside the core of the toroid:
Consider a circle of radius r in the region enclosed by the turns of the toroid. Now we apply Ampere's circuital law to this circular path, i.e.

$\oint B \cdot dl = \mu_0 I$

$\oint B\, dl \cos 0^\circ = \mu I$

$B\ 2\pi r = \mu_o I$

$\because$ Current enclosed by circular path $= (n 2\pi r) I$

$B 2\pi r = \mu_o\ n 2\pi r I$

$B = \mu_o n I$

OR

Torque on a current-carrying loop: Consider a rectangular loop PQRS of length l, breadth *b*, suspended in a uniform magnetic field $\vec{B}$. The length of loop $= PQ = RS = \ell$ and breadth $QR = SP = b$.

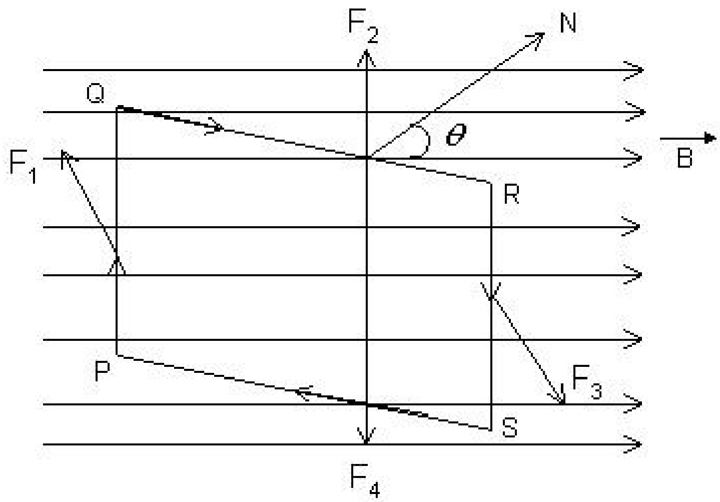
Let at any instant the normal to the plane of the loop make an angle θ with the direction of the magnetic field B and I is the current in the loop.

We know that a force acts on a current-carrying wire placed in a magnetic field. Therefore, each side will experience a force. The net force and torque acting on the loop will be determined by the forces acting on all sides of the loop. Suppose that the forces on side PQ, QR, RS and SP are F_1, F_2, F_3 and F_4, respectively. The sides QR and SP make angle $(90^\circ - \theta)$ with the direction of B. Therefore, each of the forces F_2 and F_4 acting on these sides has the same magnitude.

$F^1 = Blb \sin(90^\circ - \theta) = Blb \cos\theta$

According to Fleming's left-hand rule, the forces F_2 and F_4 are equal and opposite, but their line of action is the same. Therefore, these forces cancel each other, i.e. the resultant of F_2 and F_4 is zero.

Axis of the loop or normal to the loop:



Sides PQ and RS of the current loop are perpendicular to B ; therefore, the magnitude of each of the forces F_1 and F_3 is

$F = IlB\sin 90^\circ = IlB$

According to Fleming's left-hand rule, the forces F_1 and F_3 acting on sides PQ and RS are equal and opposite, but their lines of action are different. Therefore, the resultant force of F_1 and F_3 is zero, but they form a couple called the deflecting couple.

Moment of couple or torque

$\tau = \text{force} \times$ perpendicular distance

$\tau = (BIl)\,b\sin\theta = I(lb)B\sin\theta$

$\because \quad lb = \text{area of loop}\,(A)$

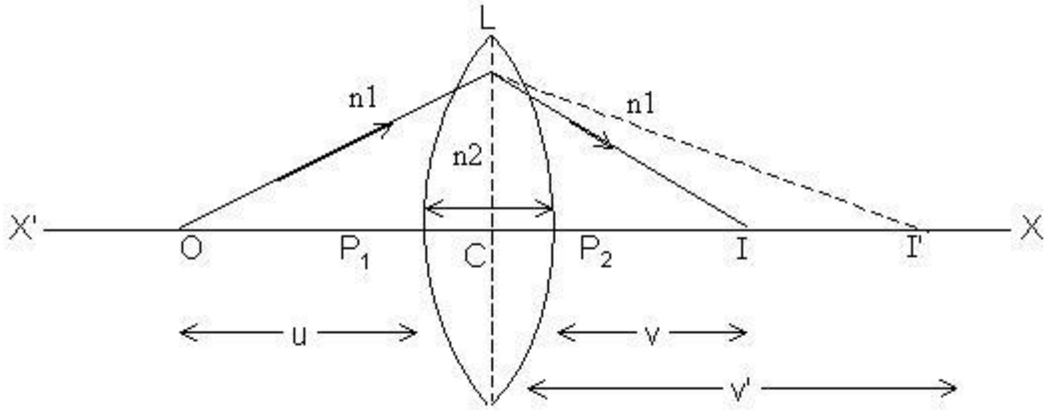
$\therefore \quad \tau = IAB\sin\theta$

If the loop contains N – turns, then

$\tau = NIAB\sin\theta$

32. Lens maker's formula: Suppose L is a thin lens. The refractive index of the material of the lens is n_2 and it is placed in a medium of refractive index n_1. The optical centre of the lens is *c* and x' x is the principal axis. The radii of curvatures of the surfaces of the lens are R_1 and R_2, and their poles are P_1 and P_2. The thickness of the lens is t, which is very small. O is a point object on the principal axis of the lens. The distance of the object from pole P_1 is u. The first refracting surface from an image of O at I' is at a distance v' from P_1.

From the refraction formula at the spherical surface, we have



$\because \quad \frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R_1} \qquad (1)$

The image I' acts as a virtual object for the second surface, and after refraction at the second surface, the final image is formed at I. The distance of I from pole P_2 of the second surface is v. The distance of the virtual object (I') from pole P_2 is $(v' - t)$.

For refraction at a second surface, the ray is going from the second medium (refractive index n_2) to the first medium (refractive index n_1); therefore, from the refraction formula at the spherical surface, we have

$$\frac{n_1}{v} - \frac{n_2}{(v' - t)} = \frac{n_1 - n_2}{R_2} - \qquad (2)$$

For a thin lens, t is negligible as compared to v', from (2).

$$\frac{n_1}{v} - \frac{n_2}{(v')} = -\frac{n_2 - n_1}{R_2} \qquad -(3)$$

Adding equations (1) and (3), we get

$$\frac{n_1}{v} - \frac{n_1}{u} = (n_2 - n_1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{v} - \frac{1}{u} = \left[\frac{n_2}{n_1} - 1\right]\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{v} - \frac{1}{u} = ({}_1n_2 - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \quad -(4)$$

where ${}_1n_2 = \frac{n_2}{n_1}$ is the refractive index of the second medium with respect to the first medium.

If the object O is at infinity, then the image will be formed at the second focus, i.e.

$u = \infty, \quad v = f_2 = F$

Therefore, from equation (4),

$$\frac{1}{F} - \frac{1}{\infty} = ({}_1n_2 - 1) = \left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{F} = ({}_1n_2 - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \text{ - (5)}$$

This is the formula of refraction for a thin lens. The formula is called the lens maker's formula.

If the first medium is air and the refractive index of the material of the lens is n, then ${}_1n_2 = n$; therefore,equation (5) may be written as

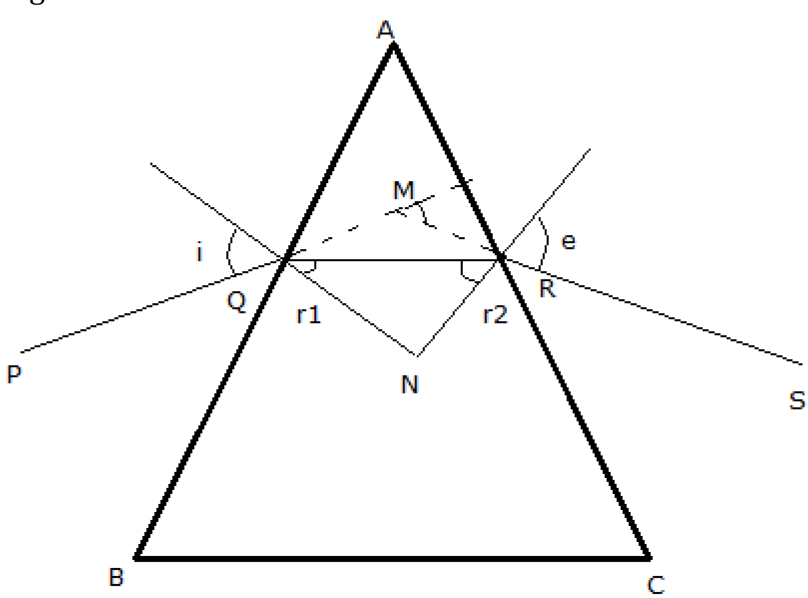
$$\frac{1}{F} = (n - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

OR

The figure shows the passage of light through a triangular prism ABC. The angles of incidence and refraction at the first face AB are i and r1 while the angle of incidence (from glass to air) at the second face AC is r2 and the angle of refraction or emergence e. The angle between the emergent ray RS and the direction of the incident ray PQ is called the angle of deviation δ.

In the quadrilateral AQNR, two of the angles (at the vertices Q and R) are right angles. Therefore, the sum of the other angles of the quadrilateral is 180°.

From the triangle



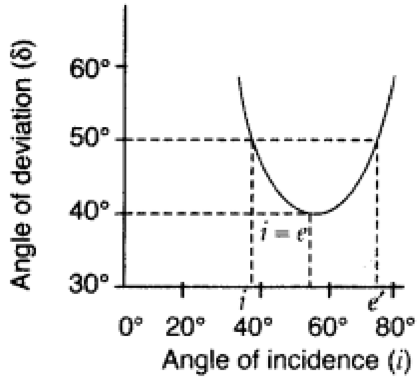
Comparing these two equations, we get

$r_1 + r_2 = A$

The total deviation δis the sum of deviations at the two faces,

$\delta = (i - r_1) + (e - r_2)$

$\delta = i + e - A$ - - - - - - - - - (i)



A plot between the angle of deviation and angle of incidence is shown in the figure. In general, any given value of δ, except for i = e, corresponds to two values i and hence of e. This, in fact, is expected from the symmetry of i and e in equation (i) above, i.e., δ remains the same if i and e are. interchanged. Physically, this is related to the fact that the path of ray in the diagram above can be traced back, resulting in the same angle of deviation. At the minimum deviation dm, the refracted ray inside the prism becomes parallel to its base. We have,

δ=dm

When angle of incidence (i) and angle of emergence (e) are equal, ie,

Angle i= angle r

$$\mu = \frac{\sin\left(\frac{A + d_m}{2}\right)}{\sin\frac{A}{2}}$$

$\angle A = \angle d_m$

$$\mu = \frac{\sin\left(\frac{A + d_m}{2}\right)}{\sin\frac{A}{2}} = \frac{\sin A}{\sin\frac{A}{2}} = \frac{2\sin\frac{A}{2}\cos\frac{A}{2}}{\sin\frac{A}{2}}$$

$$= 2\cos\frac{A}{2} = 2\cos 30^0 = 2 \times \frac{\sqrt{3}}{2} = 1.732$$

33. (i) The logic gate shown is the OR gate.

(ii)The truth table of the OR gate is

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

(iii) The input wave forms A and B are discrete square waves.
For convenience, the components of the wave fronts A and B are shown by vertical dotted lines.

Between a & b, A = 1, B = 1 $\rightarrow$ y = 1

Between b & c, A = 0, B = 0, $\rightarrow$ y = 0

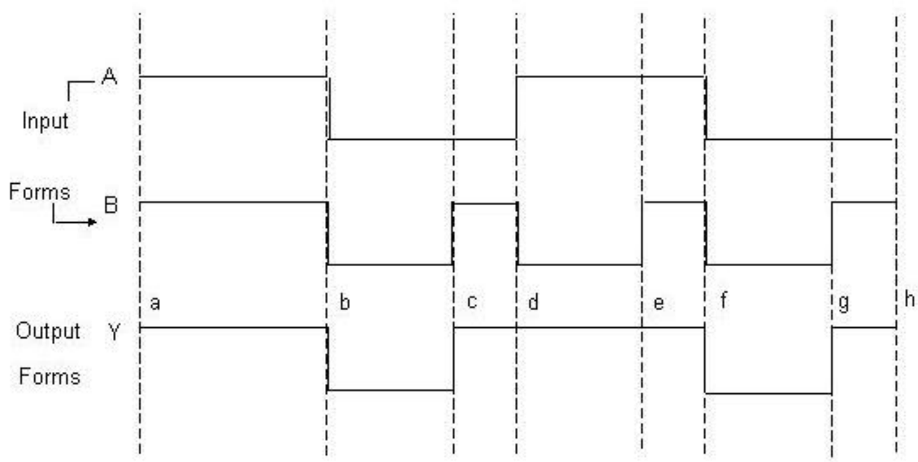
Between c & d, A = 0, B = 1, $\rightarrow$ y = 1

Between d & e, A = 1, B = 0 $\rightarrow$ y = 1

Between e & f, A = 1, B = 1 $\rightarrow$ y = 1

Between f & g, A = 0, B = 0 $\rightarrow$ y = 0

Between g & n, A = 0, B = 1 $\rightarrow$ y = 1



OR

(a) $\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{2\text{ mA}}{20\ \mu\text{A}} = 100$

(b) The input resistance $R_{BE} = \frac{\Delta V_{BE}}{\Delta I_B} = \frac{20\text{ mV}}{20\ \mu\text{A}} = 1\text{ k}\Omega$

(c) Transconductance = $\frac{\Delta I_C}{\Delta V_{BE}} = \frac{2\text{ mA}}{20\text{ mV}} = 0.1\text{ mho}$

(d) The change in input voltage is $R_L \Delta I_C = (5\ k\Omega)(2\ mA) = 10\ V$

The applied signal voltage = 20 mV

Thus, the voltage gain is

$$= \frac{10\ V}{20\ mV} = 500$$