CBSE Board
Class XII Physics

Time: Three Hours **Maximum Marks: 70**

General Instructions

(a) All questions are compulsory.

(b) There are 29 questions in total. Questions 1 to 8 carry one mark each, questions 9 to 16 carry two marks each, questions 17 to 25 carry three marks each and questions 27 to 29 carry five marks each.

(c) Question 26 is a value based question carrying four marks.

(d) 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.

(e) Use of calculator is not permitted.

(f) You may use the following physical constants wherever necessary.

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

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

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

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

$K_B = 1.38 \times 10^{23}$ J K^{-1}

$N_A = 6.023 \times 10^{23}$ /mole

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

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1. Two point charges +q & -q are situated at a distance d from each other. At which points will the resultant electric field will be parallel to the line joining the two charges? (1)

2. Which two magnetic properties are revealed by the study of hysteresis loops of different materials? (1)

3. A coil is removed from a magnetic field i) rapidly ii) slowly. In which case more work will be done? Why? (1)

4. When current flows through the coil of the transformer, the core of the transformer gets hot. Why? (1)

5. Why is ground waves transmission not advisable for the em waves of frequencies beyond 1500 kHz? (1)

6. What is the effect on the interference fringes when:

(i) one of the slits is so painted that it transmits half the intensity of the other?

(ii) if one of the two slits is covered? (1)

7. How does the maximum kinetic energy of electrons emitted vary with work function of the metal? (1)

8. Draw energy band diagram of p type semiconductor. (1)

9. What is the shape of equipotential surfaces around a point charge? Can two equipotential surfaces intersect? Justify your answer. (2)

10. Find the capacitances of three parallel plates, each of area A m^2 and separated by d_1 and d_2 metres. The in-between spaces are filled with dielectrics of relative permittivity ε_1 and ε_2. The permittivity of free space is ε_o. (2)

11.

(a) You are to measure an emf of the cell. What will you use, a high resistance voltmeter or a potentiometer? Why?

(b) Give two reasons why copper wire is not typically used in potentiometer? (2)

12. A galvanometer coil has a resistance of 12 Ω and the meter shows full scale deflection for a current of 3 mA. How will you convert the galvanometer into a voltmeter of range 0 to 18 V? (2)

13. Name the type of modulation scheme preferred for digital communication. How does the power radiated by an antenna vary with wavelength? (2)

14.

(a) A conducting loop is held stationary normal to the field between the NS poles of a fixed permanent magnet. By choosing a magnet sufficiently strong, can we hope to generate current in the loop?

(b) A closed conducting loop moves normal to the electric field between the plates of a large capacitor. Is a current induced in the loop when it is

(i) wholly inside the capacitor

(ii) partially outside the plates of capacitor?

The electric field is normal to the plane of the loop. (2)

15. Draw the phasor diagram to represent the relation between instantaneous current & voltage in an ac circuit with capacitor only. What is the phase difference between two in capacitive ac circuit? (2)

16. If a clear blue portion of the sky is seen through a rotating Polaroid, variation in the intensity of light is observed. Why is it so? (2)

OR

What is the principle of working of:

(i) Light emitting diode?

(ii) Solar cell? (2)

17. A potential difference V exists across a copper wire of length L & diameter d. How is the drift velocity affected if i) V is doubled, ii) L is doubled, and iii) d is doubled? (3)

18. In a.c. circuits:

(a) When an LCR circuit is brought into resonance, the current has a large value. Why? When does the LCR circuit become purely resistive?

(b) Can a capacitor of suitable capacitance replace a choke coil in an ac circuit? (3)

19. A small bulb is placed at the bottom of a tank containing water to a depth of 80cm. What is the area of the surface of water through which light from the bulb can emerge out? Refractive index of water is 1.33. (Consider the bulb to be a point source) (3)

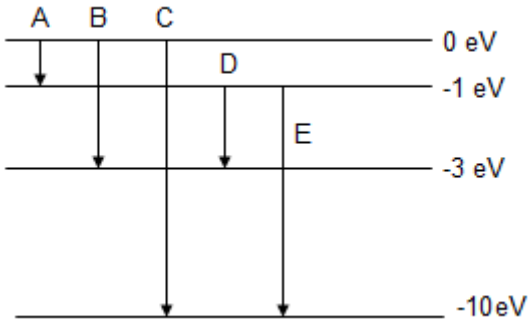
OR

A concave lens has the same radius of curvature for both sides and has a refractive index 1.5 in air. In the second case, it is immersed in a liquid of refractive index 1.4. Calculate the ratio of the focal length of the lens in the two cases. (3)

20. What is a Polaroid? How plane polarized light is obtained with its help? How will you use it to distinguish between unpolarised & polarised light? (3)

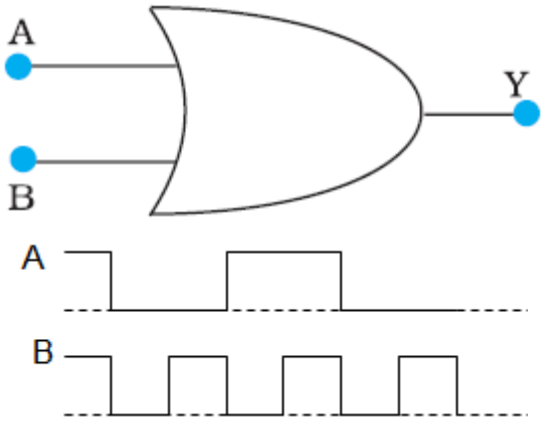
21. From the relation $R = R_0A^{1/3}$, where R_0 is a constant and A is the mass number of a nucleus, show that the nuclear matter density is nearly constant (i.e. independent of A). What is the relation between the binding energy per nucleon & stability of the nucleus? (3)

22. The energy levels of an atom of element are shown in the following diagram. Which one of the level transitions will result in the emission of photons of wavelength 620 nm? Support your answer with mathematical calculations.



(3)

23. In the figure below, circuit symbol of a logic gate & two input waveforms 'A' and 'B' are shown.



(i) Name the logic gate.
(ii) Write its truth table.
(iii) Give the output waveform. (3)

24.

(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 AM signal? (3)

25. For a series LCR circuit, draw a graph showing the variation of current with angular frequency of the source for a particular value of resistance. On the graph mark the angular frequencies for which the power is ½ the maximum value. Also mark the bandwidth. (3)

26. Geeta's father was riding the bike on highway and she was sitting behind him. While riding, at a place traffic signal turned red from green and her father continued riding without noticing the signal change. Geeta observed the whole situation and asked her father to stop. Her father felt happy on her daughter's intelligence.

(a) Why Geeta's father became happy? What king of value is expressed by Geeta?
(b) What are the principles that are used in maintaining traffic signals? What is the leading physical quantity in the process? Write an equation for the speed of the photoelectron. (4)

27.

(a) When a tiny circular obstacle is placed in the path of light from the distant source, a bright spot is seen at the centre of the shadow of the obstacle. Explain.
(b) In a single slit experiment, the width of the slit is made double the original width. How does this affect the size & intensity of the central diffraction band?
(c) Two slits are made one millimetre apart and the screen is placed one metre away. What should the width of each slit be, so as to obtain 10 maxima of the double slit pattern within the central maximum of the single slit pattern?
(d) Draw an intensity distribution graph for diffraction due to single slit & that for interference due to double slits. State one important point of difference between these two intensity patterns. (5)

OR

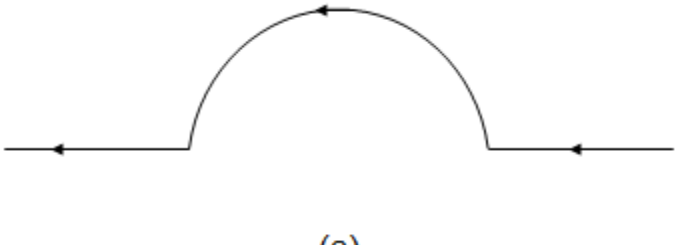
Explain the principle and working of a cyclotron with the help of a labeled diagram. For a cyclotron having oscillator frequency as $10 MHz$, what should be the operating magnetic field for accelerating protons? If the radius of its 'dees' is 60 cm, what is the kinetic energy of the proton beam produced by accelerator? Express your answer in units of MeV. (5)

$\left(e = 1.6 \times 10^{-19} C,\ m_p = 1.67 \times 10^{-27} kg,\ 1 MeV = 1.602 \times 10^{-13} J\right)$

28.

(a) By mistake a voltmeter is connected in series & ammeter in parallel with a resistance in an electrical circuit. What will happen to the instrument?

(b) A thick straight copper wire carrying a current of 10 A is bent into a semi circular arc of radius 7 cm as shown in the figure a. State the direction & calculate the magnitude of magnetic field at the centre of the arc. How will your answer change if the same wire were bent into a semicircular arc of the same radius but in opposite direction as shown in Fig b?



(a)

(b)

(c) Free electrons inside the conductor are in random motion at all times. Even then, no magnetic force acts on them in a magnetic field unless a current is passed through it. Why? (5)

OR

(a) What are the coherent sources of light? Why are coherent sources required to obtain sustained interference pattern?

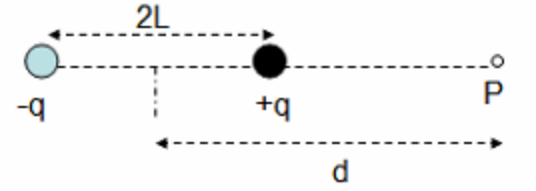
(b) State three characteristic features which distinguish the interference pattern due to two coherently illuminated sources as compared to that observed in a diffraction pattern due to a single slit. (5)

29.

(a) An electric dipole is placed in an external uniform electric field $\vec{E}$. What is the torque acting on the dipole? What is the net force experienced by the dipole?

(b) Electric charge is uniformly distributed on the surface of an inflated spherical balloon. State how the values of electric field intensity E and potential V vary on i) surface, ii) inside and iii) outside.

(c) As shown in the figure, calculate the net potential at point P due to two charges +q &-q situated in air.



(5)

OR

(a) State Lenz's law. Which conservation law can be used to explain this law?

(b) A wheel with 10 metallic spokes each 0.5m long is rotated with a speed of 120rev/min in a plane normal to the horizontal component of earth's magnetic field at a place where the earth's field is 0.4×10^{-4}G. What is the induced emf between the axle and the rim of the wheel?

(c) Two moving coil meters, M_1 and M_2 have the following particulars:

$R_1 = 10\ \Omega$, $N_1 = 30$,

$A_1 = 3.6 \times 10^{-3}\ m^2$, $B_1 = 0.25$ T

$R_2 = 14\ \Omega$, $N_2 = 42$

$A_2 = 1.8 \times 10^{-3}\ m^2$, $B_2 = 0.50$ T

(The spring constants are identical for the two meters). Determine the ratio of (a) current sensitivity and (b) voltage sensitivity of M_2 and M_1. (5)

CBSE Board
Class XII – Physics
Solution

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1. At points on the line joining the two charges & on the right bisector of this line.

2. Magnetic properties like retentivity, coercivity, hysteresis loss, etc. are revealed by the study of hysteresis loops of different materials.

3. More work will be done in removing the coil rapidly.
This is because while moving the coil rapidly, the rate of change in magnetic flux will be greater, and hence larger opposing emf will be induced.

4. When alternating current passes through the coil of the transformer, the core magnetizes & demagnetizes repeatedly. The electrical energy taken by the core during magnetization is not returned fully in demagnetization. The energy remaining in the core during demagnetization appears as heat. This is known as hysteresis loss.

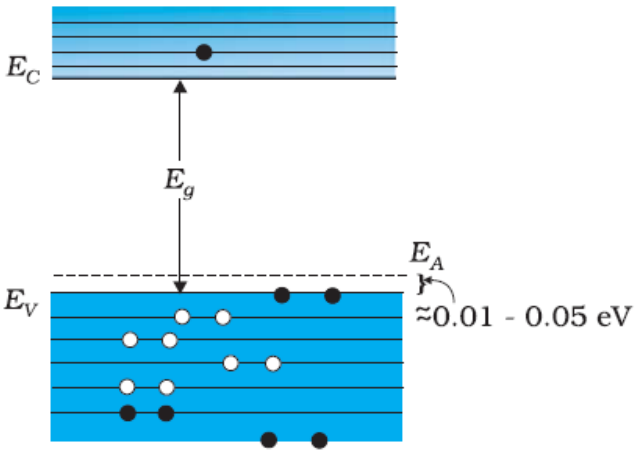
5. Attenuation or absorption of ground waves increases with increase in frequency in the ground wave transmission.

6.

(i) The contrast between the bright & dark fringes decreases.
(ii) diffraction pattern will be formed instead of interference pattern on the screen.

7. As $\frac{1}{2}mv_{max}^2 = h\nu - W_o$, increase in the work function of the metal surface will lower the value of the maximum kinetic energy of the electrons emitted.

8.



9.

Equipotential surfaces around a point charge will be concentric spherical shells centered at the point charge.

No two equipotential surfaces intersect each other.

If they do, then at the point of intersection, there will be two directions of electric field which is not possible.

10. The system is equivalent to two capacitors connected in series.

Capacitance $C_1 = \frac{\varepsilon_1 \varepsilon_o A}{d_1}$

Capacitance $C_2 = \frac{\varepsilon_2 \varepsilon_o A}{d_2}$

C_1 & C_2 in series,

$\Rightarrow$

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\frac{1}{C} = \frac{1}{\varepsilon_o A}\left(\frac{d_1}{\varepsilon_1} + \frac{d_2}{\varepsilon_2}\right)$$

$$\frac{1}{C} = \frac{1}{\varepsilon_o A}\left(\frac{d_1\varepsilon_2 + d_2\varepsilon_1}{\varepsilon_2\varepsilon_1}\right)$$

$$C = \frac{\varepsilon_2\varepsilon_1\varepsilon_o A}{d_1\varepsilon_2 + d_2\varepsilon_1}$$

11.

(a) We use potentiometer for measuring emf of a cell. A voltmeter measures p.d & not its emf because it draws some current from the cell. Potentiometer on the other hand, draws no current from the cell at balance point.

(b)

(i) Specific resistance of copper is small.

(ii) Temperature coefficient of resistance is large

12. Galvanometer resistance = G = 12 Ω

Full scale deflection current I_g = 3 mA

Maximum voltage to be measured = 18 volt = V_o

∴ Series resistance to be connected in series with the galvanometer is

$$R = \left(\frac{V_o}{I_g} - G\right)$$

$$\therefore R = \left(\frac{18}{3\times10^{-3}} - 12\right)\Omega = (6000 - 12)\Omega = 5788\,\Omega$$

13. For digital communication we prefer pulse code modulation (P.C.M).

The power radiated by an antenna is related to wavelength by relation,

$$P \propto \frac{1}{\lambda^2}$$

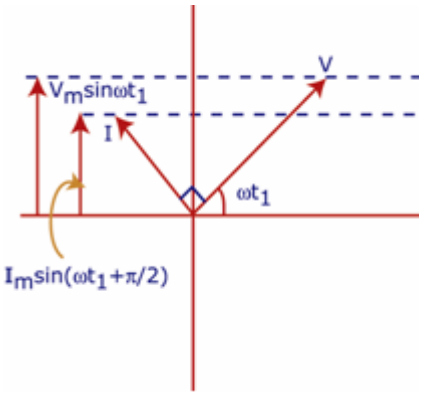
14.

(a) No, change in flux is required to induce emf. It is not the absolute value of the flux, but its rate of change that determines emf.

$$\in = -\frac{d\phi}{dt}$$

(b) No, emf is induced in either case. Emf is induced by change in magnetic and, not by varying electric flux in a given region.

15.



The instantaneous current leads the applied voltage by $\frac{\pi}{2}$ in a purely capacitive circuit.

16.

This is due to polarization of light as sunlight gets scattered by atmosphere gas molecules. This scattered light when seen perpendicular to the direction of incidence is found to be plane polarized.

When this plane polarized light is seen through a Polaroid which is rotated, its intensity changes with rotation.

OR

(i) Due to recombination of electrons & holes, energy is released in the junction region. If this energy released falls in the visible region, then such diodes are called light emitting diodes or LED's.

(ii) The incident light falls on p-n junction & generates electron holes pairs. The electrons acquire energy & move towards n region developing potential across the diode & current flows through the circuit.

17.

(i) When V is doubled, the current I in the wire is doubled, and hence the drift velocity v_d will also be doubled as $v_d = I/neA$.

(ii) When L is doubled, the resistance will be doubled and hence the current will be halved. Hence, drift velocity will also be halved.

(iii) When diameter is halved, the area of cross section of the wire becomes four times and so the current will become 4 times as the resistance becomes one-fourth. Therefore, $v_d = I/neA$, will remain unchanged.

18.

(a) The impedance in LCR series circuit is

$$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

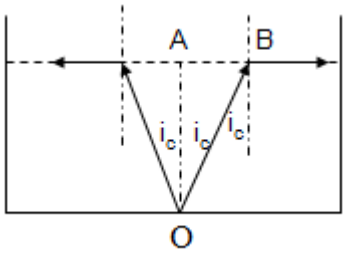
At resonance, $\omega L = \frac{1}{\omega C}$

So, the impedance takes up the minimum value, that is, Z = R. Hence, the current in the circuit at resonance will be maximum.

The LCR circuit in series can become purely resistive at resonance when $\omega L = \frac{1}{\omega C}$. In such a case, circuit will be purely resistive.

(b) Yes. Because the average power consumed in a capacitor is also zero. Hence, like a choke coil, a capacitor can reduce current in ac current without power dissipation.

19.



Angle is4

$$\sin i_c = \frac{1}{{}_a\mu_w}$$

$$\Rightarrow i_c = \sin^{-1}\frac{1}{{}_a\mu_w} = \sin^{-1}\frac{1}{1.33} = 48.7^o$$

Also from the figure, we have

$$\tan i_c = \frac{AB}{AO}$$

$$AB = AO\tan i_c = 80x1.14 = 91.2cm$$

So, the area of patch of light = $\pi\,(91.2)^2 = 2.61\ m^2$

OR

Given that:

$R_1 = r$

And $R_2 = -r$

Refractive index of lens with respect to air $\mu_a = 1.5$

Refractive index of lens with respect to liquid $\mu_l = \frac{1.5}{1.4}$

Then, $\frac{1}{f_1} = (\mu_a - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$\frac{1}{f_1} = (1.5 - 1)\left(\frac{1}{r} + \frac{1}{r}\right)$

$\frac{1}{f_1} = 0.5 \times \frac{2}{r}$

$f_1 = r$

Thus, the focal length of lens for air medium is equal to the radius of curvature of its surfaces.

Again, for liquid medium, we have

$\frac{1}{f_2} = (\mu_l - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$= \left(\frac{(1.5 - 1)}{1.4}\right)\left(\frac{1}{r} + \frac{1}{r}\right)$

$\frac{1}{f_2} = \frac{0.1}{1.4} \times \frac{2}{r}$

$\frac{1}{f_2} = \frac{1}{7r}$

$f_2 = 7r$

Thus, the focal length for liquid medium is 7 times the radius of curvature of its surfaces.

Hence, the ratio is

$\frac{f_1}{f_2} = \frac{1}{7}$

20. Polaroid is a material that polarizes an unpolarised light.

Example: tourmaline.

Polaroid produces plane polarised light by selective absorption. A Polaroid has a characteristic plane called transmission plane. When unpolarised light falls on a Polaroid, only those vibrations get transmitted which are parallel to the transmission plane.

When a Polaroid is placed in the path of light and is rotated, if the light continues to emerge out of the Polaroid, then the incident light is unpolarised light.

In case we get zero intensity & maximum intensity of light alternately for a rotation for every 90^o, the light falling on the Polaroid is plane polarized.

21. Mass of nucleus = mA, where m is the average mass of the nucleon, A is the mass number of element.

$$\text{Volume of nucleus} = \frac{4}{3}\pi R^3$$

Where, R is radius of the nucleus.

Density of nuclear matter is

$$\rho = \frac{mA}{\frac{4}{3}\pi R^3} = \frac{mA}{\frac{4}{3}\pi R_o^3 A} = \frac{3m}{4\pi R_o^3}$$

Here, $m = 1.66 \times 10^{-27}$ kg

$R_o = 1.2 \times 10^{-15}$ m

So,

$$\rho = \frac{3m}{4\pi R_o^3} = \frac{3x1.66x10^{-27}}{4x3.14x(1.2x10^{-15}m)^3}$$

$$\rho = 2.98x10^{17}\,kg/m^3$$

Larger the binding energy per nucleon, greater is the stability of the nucleus.

22. Energy of the photon of wavelength λ is $E = \frac{hc}{\lambda}$

Here $\lambda = 620$ nm $= 620 \times 10^{-9}$ m

$$E = \frac{hc}{\lambda} = \frac{6.62x10^{-34}x3x10^8}{620x10^{-9}}\,J$$

$$= \frac{6.62x10^{-34}x3x10^8}{620x10^{-9}x1.6x10^{-19}}\,eV = 2eV$$

Transition D will result in the emission of photons of wavelength 620 nm. (1)

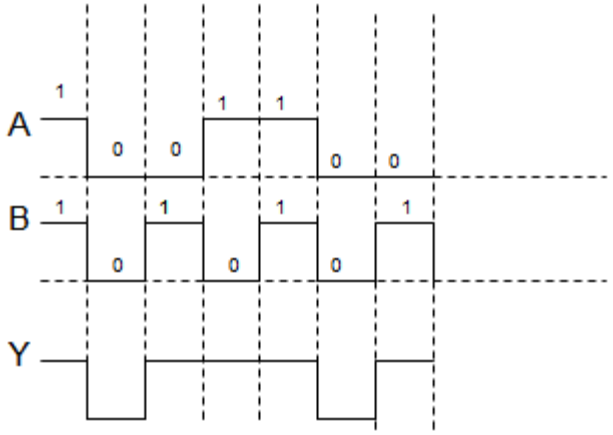
23.

(i) The logic gate is an OR gate

(ii)

A	B	A+B=Y
0	0	0
0	1	1
1	0	1
1	1	1

(iii)



24.

(a) Advantages of pulse code modulation over amplitude modulation:

(i) Free from noise and interfering signals

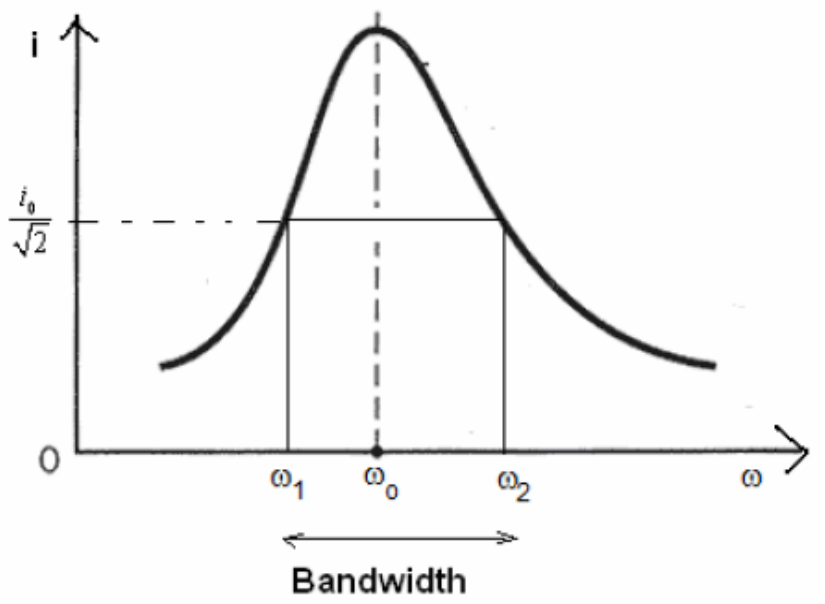
(ii) ii. Allows coded electrical signals

(b) Range of FM signals: 88 MHz to 108 MHz.

Firstly, the FM signals are in the form of frequency variation, so they do not get disturbed by the noise generated by atmospheric or man-made electrical discharge.

Secondly, the amplitude variations due to noise in FM signals can be easily removed prior to demodulation.

25.



Drawing of the graph correctly with proper labels on x and y axis
Marking ω_1 and ω_2 on the graph
Marking bandwidth on the graph

26.

(a) Geeta's father was proud and happy on his daughter's presence of mind, awareness of traffic rules with high visual sensibility.

(b) Principle of photoelectric effect is used to maintain the traffic signals.
The leading physical quantity of photoelectric current is the photoelectrons.
The required equation is

$$v = \sqrt{\frac{2E}{m} - \frac{2\phi}{m}}$$

Here,
v = speed of the electron
E = energy of the photon
m = mass of the electron and
ϕ = work function for the metal

27.

(a) The waves diffracted from the edge of the obstacle interfere constructively at the centre of the shadow and give a bright spot.

(b) The width of central maximum = $2\lambda D/a$.
If the slit width a is doubled, the width of the central maximum will be halved.

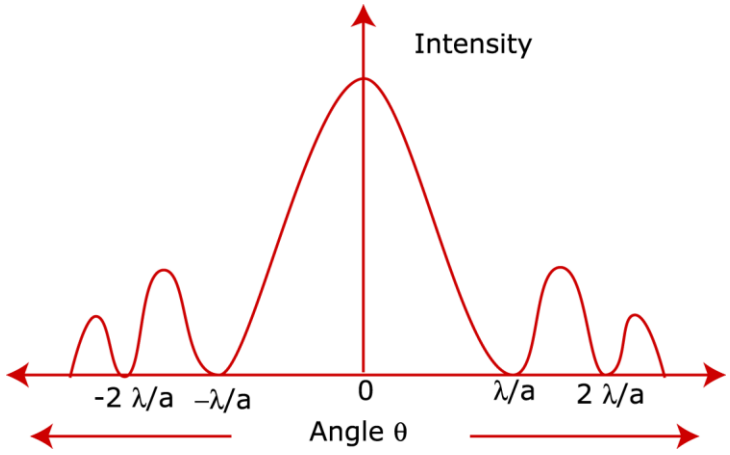
Intensity of the light at the central maximum will become four times.

(c) We want angular width of central maxima

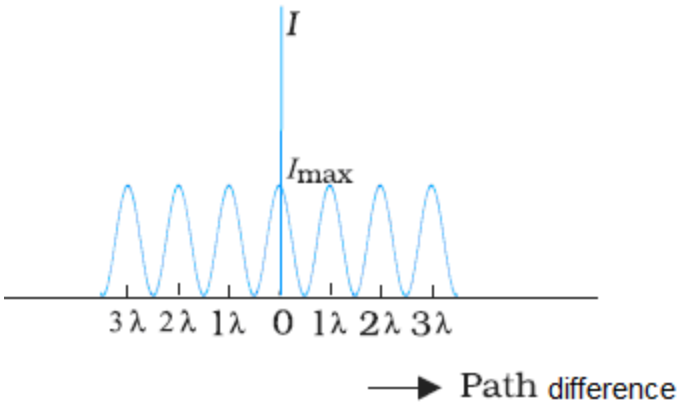
$$a\theta = \lambda,\ \theta = \frac{\lambda}{a}$$

$$10\frac{\lambda}{d} = 2\frac{\lambda}{a}:\quad a = \frac{d}{5} = 0.2\,\text{mm}$$

(d) Due to diffraction:



Due to interference:



One important point of difference:

All bright fringes in interference pattern are of same intensity whereas in case of diffraction, the intensity of the fringes decreases as we move away from the centre.

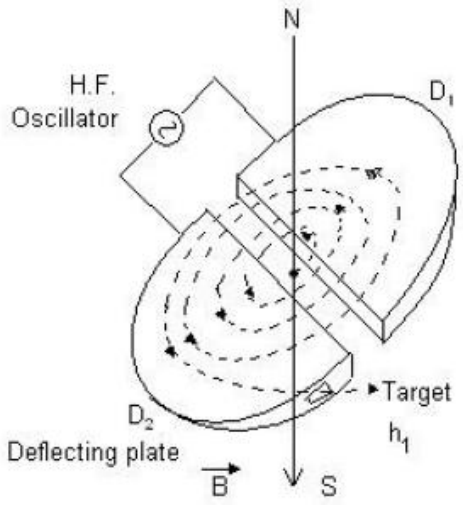
OR

Principle of Cyclotron

A positive ion can be accelerated to a very high energy by making it pass through a moderate electric field again and again by making use of magnetic field. (1)

Working:

High frequency oscillator maintains a modest alternating potential difference between the dees. Suppose positive ion produced at any instant finds D_1 at negative potential. It gets accelerated towards it.



Perpendicular magnetic field makes it move in a circular path. Particle traces a semicircular path of radius r such that

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

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

The time taken 't' is equal to half time period of electric oscillator. Hence, as soon as the ion arrives in the gap between the dees, the polarity of the dees is reversed and positive ion gets accelerated towards D_2. This way the ion keeps on accelerating until it is removed out of the dees by applying deflecting electric field across a window.

$$\frac{1}{2}$$

Given that $v = 10 \times 10^6$ Hz, $R = 0.6$ m

Kinetic energy =?

At resonance

$$v = \frac{Bq}{2\pi m}$$

$$B = \frac{2\pi mv}{e} \qquad (\because q = e)$$

$$B = \frac{2 \times 3.14 \times 1.67 \times 10^{-27} \times 10^{7}}{1.6 \times 10^{-19}}$$

$$B = 0.66T$$

Kinetic energy $= \frac{B^2 e^2 R^2}{2m}$

$$= \frac{(0.66)^2 \times (1.6 \times 10^{-19})^2 \times (0.6)^2}{2 \times 1.67 \times 10^{-27}}$$

$$= 7.5MeV$$

28.

(a) Let R_A and R_v be the resistance of ammeter and voltmeter respectively and R be the resistance of the circuit.

Since R >> R_A and R_v >> R, when the voltmeter is connected in series & ammeter in parallel with resistance R, the net resistance of the circuit will be nearly R_v.

If E is the emf of the battery connected in the circuit, the current $I \approx \frac{E}{R_v}$.

This entire current flows through the voltmeter connected in series and R >> R_A and nearly whole of current I also passes through the ammeter.

If they were connected correctly, then the current in the circuit would have been

$I_o = \frac{E}{R}$.

As, R<<R_v, I <<I_o

So no instrument will be damaged, i.e., neither ammeter nor voltmeter will be damaged.

(b) The magnetic field in (a) will point towards us & in (b) will point away from us, but both are perpendicular to the plane of the paper.

Magnitude of the magnetic field at the centre point:

Given: I = 10 A; r = 7 cm

$B_1 = B_2 =$

$$= \frac{\mu_o I}{4r} = \frac{4\pi x10^{-7} x10}{4x7x10^{-2}} = \frac{\pi}{7} x10^{-4} T$$

(c) In the absence of electric current, the free electrons in a conductor are moving randomly such that the average velocity is zero, so net force on them is zero. On passing the current, the free electrons align themselves in the direction of the applied electric field and have a certain drift velocity in definite direction. Hence, a net resultant magnetic force acts on them.

OR

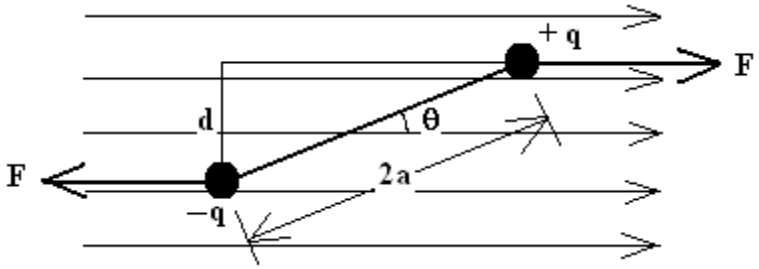
(a) Coherent Sources of light: Two sources with same frequencies having a (time independent) stable phase difference or zero phase difference.
If phase difference is variable, the interference term averages to zero. In case of stable phase difference between coherent sources, intensity at each point will vary and so sustained interference will be observed.

Difference between interference and diffraction pattern formed due to a single slit:

Interference	Diffraction
All bright and dark fringes are of equal width.	Width of secondary maxima keeps on decreasing.
At $\theta = \lambda / a$, a bright fringe is formed.	At $\theta = \lambda / a$, a dark fringe is formed.
Pattern is formed due to superposition of two different wave fronts.	Pattern is formed due to superposition of wavelets of the same wave front.

29.

(a) Both the charges of an electric dipole is placed in an external uniform electric field will experience force.



The force on charge – q = $E\,q$ which acts towards – x direction.
The force on charge + q = $E\,q$ which acts in the +x direction.

Both these forces are equal in magnitude and opposite in direction, there is no net force acting on the electric dipole as a whole.

However, if the axis of the dipole makes an angle θ with the direction of $\vec{E}$, then we observe that the lines of action of the two forces do not coincide.

Therefore, although there is no net force acting on the dipole, there is a net torque acting about its centre.

By definition, the magnitude of this torque is given by

$\tau = F \times d = qE \times 2a \sin\theta$

$= 2qa \times E \sin\theta$

$= pE \sin\theta$

Here p is the magnitude of the dipole moment.

But from the definition of vector cross product we know that

$$\left|\vec{p} \times \vec{E}\right| = pE \sin\theta$$

Thus, we have

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

Since this is a cross product, $\vec{\tau}$ is perpendicular to the plane containing the vectors $\vec{p}$ and $\vec{E}$.

(b)

(i) On the surface: E is same everywhere & V is also same everywhere.

(ii) Inside the surface: E is zero & V is same everywhere.

(iii) Outside the surface: Both E & V decrease as one moves away from the surface of the balloon, E falling more rapidly.

(c) The potential at P will be algebraic sum of potential due to each of the charges +q & -q.

$$V_{+q} = k\frac{q}{(d-L)}$$

$$V_{-q} = k\frac{-q}{(d+L)}$$

Total potential at P is

$$V = V_{+q} + V_{-q}$$

$$V = k\frac{2qL}{(d^2 - L^2)}$$

OR

(a) Lenz's law states that the polarity of the induced emf is such that it tends to produce a current which opposes the change in the magnetic flux that produces it.

This law can be explained by the law of conservation of energy.

(b) Induced emf $= (1/2)\omega BR^2 = (1/2) \times 4\pi \times 0.4 \times 10^{-4} \times (0.5)^2 = 6.28 \times 10^{-5} V$

(c) Given

$R_1 = 10\ \Omega$, $N_1 = 30$, $A_1 = 3.6 \times 10^{-3}\ m^2$, $B_1 = 0.25$ T

$R_2 = 14\ \Omega$, $N_2 = 42$, $A_2 = 1.8 \times 10^{-3}\ m^2$, $B_2 = 0.50$ T

Current sensitivity is $\frac{\phi}{i} = \left(\frac{NAB}{K}\right)$

Thus, the ratio of current sensitivities is $= \frac{N_1}{N_2}\frac{A_1}{A_2}\frac{B_1}{B_2} = \frac{S_1}{S_2}$

$$= \frac{30}{42}\left(\frac{3.6}{1.8}\right)\left(\frac{0.25}{0.50}\right)$$

$$= \left(\frac{5}{7}\right)$$

Ratio of voltage sensitivities $= \left(\frac{S_1}{S_2}\right)\left(\frac{R_2}{R_1}\right)$

$$= \left(\frac{5}{7}\right)\left(\frac{14}{10}\right) = 1$$