

Time: **3 hours**; Maximum Marks: **70**

General Instructions:

1. All questions are compulsory. There are 26 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 five questions of one mark each, section B contains five questions of two marks each, section C contains twelve questions of three marks each, section D contains one value based question of four marks and section E contains three questions of five marks each.
4. 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 the three questions of five marks weightage. You have to attempt only one of the choices in such questions.
5. You may use the following values of physical constants wherever necessary:

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

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

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

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

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$$

$$4\pi\epsilon_0$$

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

$$\text{Mass of neutron} = 1.675 \times 10^{-27} \text{ kg}$$

$$\text{Mass of proton} = 1.673 \times 10^{-27} \text{ kg}$$

$$\text{Avogadro's number} = 6.023 \times 10^{23} \text{ per gram mole}$$

$$\text{Boltzmann constant} = 1.38 \times 10^{-23} \text{ J K}^{-1}$$

Section A

1. A signal of 5 kHz frequency is amplitude modulated on a carrier wave of frequency 2 MHz. What are the frequencies of the side bands produced?
2. What can be the causes of helical motion of a charged particle?
3. Define mobility of a charge carrier. What is its relation with relaxation time?
4. What is the amount of work done in moving a point charge Q around a circular arc of radius ' r ' at the center of which another point charge ' q ' is located?
5. Why can't we see clearly through fog? Name the phenomenon responsible for it.

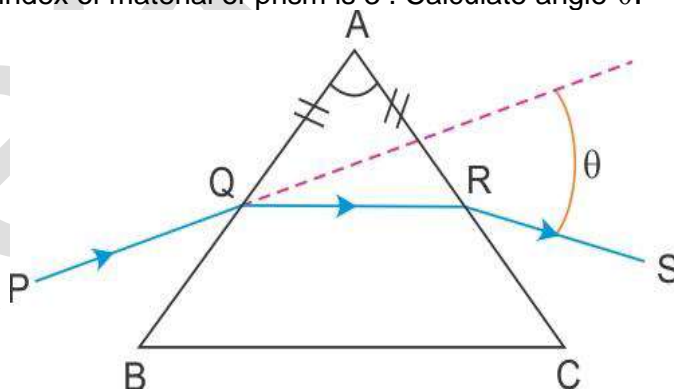
Section B

6. When is H_α line in the emission spectrum of hydrogen atom obtained? Calculate the frequency of the photon emitted during this transition.

OR

Calculate the wavelength of radiation emitted when electron in a hydrogen atom jumps from $n=\infty$ to $n=1$.

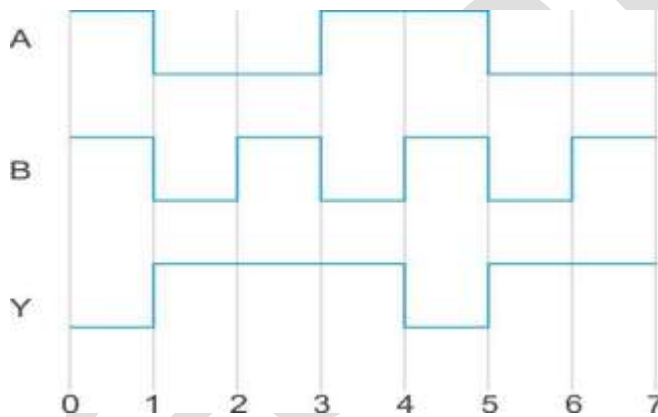
7. When 5 V potential difference is applied across a wire of length 0.1 m, the drift speed of electrons is 2.5×10^{-4} m/s. If the electron density in the wire is 8×10^{28} m⁻³, calculate the resistivity of the material of the wire.
8. A proton and an α -particle are accelerated through the same potential difference. Which one of the two has (i) greater de-Broglie wavelength, and (ii) less kinetic energy? Justify your answer.
9. A ray PQ incident on the refracting face BA is refracted in the prism BAC as shown in the figure and emerges from the other refracting face AC as RS such that $AQ = AR$. If the angle of prism $A = 60^\circ$ and refractive index of material of prism is 3. Calculate angle θ .



10. Why is base band signal not transmitted directly? Give any two reasons.

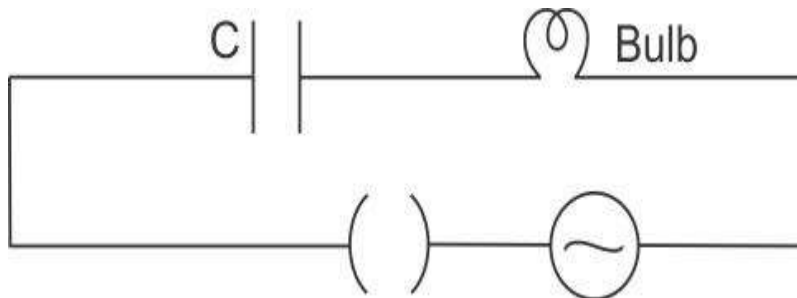
Section C

- 11.
- (i) A screen is placed at a distance of 100 cm from an object. The image of the object is formed on the screen by a convex lens for two different locations of the lens separated by 20 cm. Calculate the focal length of the lens used.
 - (ii) A converging lens is kept coaxially in contact with a diverging lens – both the lenses being of equal focal length. What is the focal length of the combination?
- 12.
- (a) Derive the mathematical expression for law of radioactive decay for a sample of a radioactive nucleus.
 - (b) How is the mean life of a given radioactive nucleus related to the decay constant?
13. What is space wave propagation? State the factors which limit its range of propagation. Derive an expression for the maximum line of sight distance between two antennas for space wave propagation.
- 14.
- (i) Distinguish between a conductor and a semi conductor on the basis of energy band diagram.
 - (ii) The following figure shows the input waveforms (A, B) and the output waveform (Y) of a gate. Identify the gate, write its truth table and draw its logic symbol.



15. (i) Name two important processes that occur during the formation of a pn junction.
 (ii) Draw the circuit diagram of a full wave rectifier along with the input and output waveforms. Briefly explain how the output voltage/current is unidirectional.
16. State two important properties of photon which are used to write Einstein’s photoelectric equation. Define (i) stopping potential and (ii) threshold frequency, using Einstein’s equation and drawing necessary plot between relevant quantities.
17. (i) Derive Snell’s law on the basis of Huygen’s wave theory when light is travelling from a denser to a rarer medium.
 (ii) Draw the sketches to differentiate between plane wavefront and spherical wavefront.

18. How are electromagnetic waves produced? What is the source of energy of these waves? Write mathematical expressions for electric and magnetic fields of an electromagnetic wave propagating along the z-axis. Write any two important properties of electromagnetic waves.
19. (i) When an AC source is connected to an ideal capacitor, show that the average power supplied by the source over a complete cycle is zero.
 (ii) A bulb is connected in series with a variable capacitor and an AC source as shown. What happens to the brightness of the bulb when the key is plugged in and capacitance of the capacitor is gradually reduced?



20. State Ampere's circuital law. Use this law to find magnetic field due to straight infinite current carrying wire. How are the magnetic field lines different from the electrostatic field lines?
OR
 State the principle of a cyclotron. Show that the time period of revolution of particles in a cyclotron is independent of their speeds. Why is this property necessary for the operation of a cyclotron?
21. Two identical cells of emf 1.5 V each joined in parallel, supply energy to an external circuit consisting of two resistances of 7Ω each joined in parallel. A very high resistance voltmeter reads the terminal voltage of cells to be 1.4 V. Calculate the internal resistance of each cell.
22. Find the electric field intensity due to a uniformly charged spherical shell at a point (i) outside the shell and (ii) inside the shell. Plot the graph of electric field with distance from the centre of the shell.

Section D

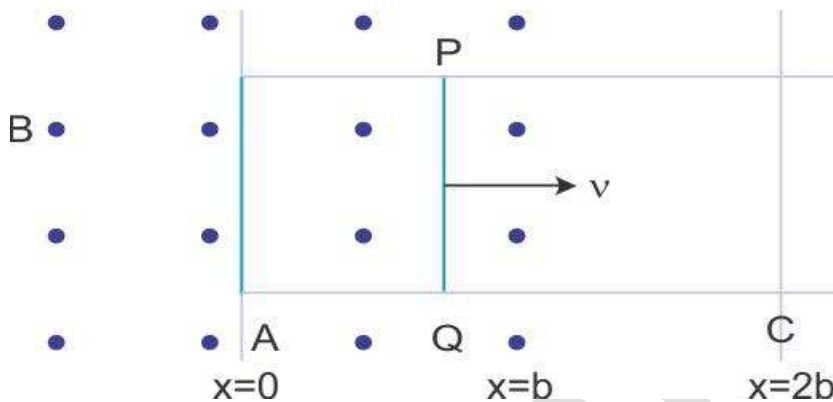
23. Seema's uncle was advised by his doctor to have an MRI (Magnetic Resonance Imaging) scan of his brain. Her uncle felt it to be expensive and wanted to postpone it. When Seema learnt about this, she took the help of her family and also approached the doctor, who also offered a substantial discount. She then convinced her uncle to undergo the test to enable the doctor to know the condition of his brain. The information thus obtained greatly helped the doctor to treat him properly.
- Based on the above paragraph, answer the following questions:
- What according to you are the values displayed by Seema, her family and the doctor?
 - What could be the possible reason for MRI test to be so expensive?
 - Assuming that MRI test was performed using a magnetic field of 0.1 T, find the minimum and maximum values of the force that the magnetic field could exert on a proton (charge = 1.6×10^{-19} C) moving with a speed of 104 m/s.

Section E

24.

(a) When a bar magnet is pushed towards (or away) from the coil connected to a galvanometer, the pointer in the galvanometer deflects. Identify the phenomenon causing this deflection and write the factors on which the amount and direction of the deflection depends. State the laws describing this phenomenon.

(b) Sketch the change in flux, emf and force when a conducting rod PQ of resistance R and length l moves freely to and fro between A and C with speed v on a rectangular conductor placed in uniform magnetic field as shown in the figure.



OR

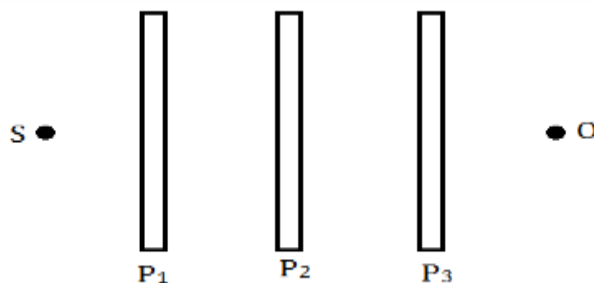
In a series LCR circuit connected to an a.c. source of voltage $v = v_m \sin \omega t$, use phasor diagram to derive an expression for the current in the circuit. Hence, obtain the expression for the power dissipated in the circuit. Show that power dissipated at resonance is maximum.

25.

(a) Why does un-polarized light from a source show a variation in intensity when viewed through a Polaroid which is rotated? Show with the help of a diagram, how un-polarized light from Sun gets linearly polarized by scattering.

(b) Three identical Polaroid sheets P₁, P₂ and P₃ are oriented so that the pass axis of P₂ and P₃ are inclined at angles of 60° and 90° respectively with the pass axis of P₁. A monochromatic source S of un-polarized light of intensity I₀ is kept in front of the Polaroid sheet P₁ as shown in the figure.

Determine the intensity of light as observed by the observer at O, when Polaroid P₃ is rotated with respect to P₂ at angles $\theta = 30^\circ$ and 60° .



- (a) Derive an expression for path difference in Young's double slit experiment and obtain the conditions for constructive and destructive interference at a point on the screen.
- (b) The intensity at the central maxima in Young's double slit experiment is I_0 . Find out the intensity at a point where the path difference is $\lambda/6$, $\lambda/4$ and $\lambda/3$.

26.

- (a) Distinguish with the help of a suitable diagram, the difference in the behavior of a conductor and a dielectric placed in an external electric field. How does polarized dielectric modify the original external field?
- (b) A capacitor of capacitance C is charged fully by connecting it to a battery of emf E . It is then disconnected from the battery. If the separation between the plates of the capacitor is now doubled, how will the following change?
 - (i) Charge stored by the capacitor.
 - (ii) Field strength between the plates.
 - (iii) Energy stored by the capacitor.
 Justify your answer in each case.

OR

- (a) Explain why, for a charge configuration, the equipotential surface through a point is normal to the electric field at that point. Draw a sketch of equipotential surfaces due to a single charge ($-q$), depicting the electric field lines due to the charge.
- (b) Obtain an expression for the work done to dissociate the system of three charges placed at the vertices of an equilateral triangle of side 'a' as shown below.

