



KEEPING MOBILE PHONE/SMART WATCH, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE

PART - A (10 X 3 = 30 Marks)

Answer ALL Questions

1. What are standing waves? How are they formed in a medium?
2. One of the Maxwell's equations forms the basis of working of electric generators. Identify that equation and explain it.
3. How does the equation of continuity change upon being applied for the case of steady state current?
4. Distinguish the concept of 'quantization' by Einstein with the one originally proposed by Max Planck in explaining blackbody radiation.
5. Find the deBroglie wavelength associated with a Coronavirus of mass  $0.9 \times 10^{-15}$  mg that is estimated to drift in air at a velocity of 2 mm/s.
6. How much energy would an electron possess in its third excited state in case it is placed inside a one-dimensional box of width  $1 \text{ \AA}$ .
7. Based on the Einstein's relation, show that building high frequency lasers is quite challenging.
8. Identify the two drawbacks found in a two-level atomic system that do not let it to be used as a laser medium.
9. Calculate the V-parameter of an optical fiber of core diameter  $50 \mu\text{m}$  with  $n_1$  and  $n_2$  being 1.5 and 1.48, respectively and hence, identify the type of fiber. Assume the operating wavelength to be 850 nm.
10. Explain why indirect bandgap semiconductors are not suitable for making light sources.

PART - B (7 X 10 = 70 Marks)

Answer ALL Questions

11. a) (i) Construct the second order, linear and partial differential equation that describes the wave propagation along a stretched string. List out the assumptions made in this derivation. Further, prove that the dimension of the expression  $\sqrt{\frac{T}{\mu}}$  represents the velocity of the wave, with the terms in the expression,  $T$  and  $\mu$  being, respectively, the tension in the string and the linear density of the string. [5]
  - (ii) Two strings of linear densities  $\mu_1$  and  $\mu_2$  that are joined and stretched with tension  $T$ . Assume a transverse wave is incident on the boundary. Calculate the reflection and transmission coefficients. The ratio of their linear densities  $\mu_1/\mu_2$  is 4. [4]
- OR
11. b) (i) Discuss the formation of wave packet by the interaction of two waves travelling in the same direction, but with a slightly different frequencies and hence arrive at the expression connecting phase and group velocities. Sketch the dispersion relation and explain the trends for normal, anomalous and non-dispersive cases. [5]
  - (ii) Find the velocity with which a plane transverse wave will progress on a wire that is stretched by a load of 500 N. The diameter and the density of the wire are, respectively,  $0.8 \text{ mm}$  and  $7.9 \text{ g/cm}^3$ . [4]



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• 12. Starting from appropriate Maxwell's equations, arrive at electromagnetic wave equations. Compare them with the classical wave equation and discuss the findings. Calculate  $\frac{1}{\sqrt{\mu_0 \epsilon_0}}$  and prove that the unit of the computed value is  $ms^{-1}$ . [10]

13. a) How did the work of Davisson and Germer confirm the wave nature of electrons? Explain why they did not observe the pronounced reflection of electrons before the occurrence of the accident in their lab. [10]

OR

• 13. b) (i) Build Schrodinger time dependent equation representing the wave equivalent of an unrestricted particle moving in the  $+x$  direction. [6]

(ii) Arrive at Bohr's postulate from deBroglie's hypothesis. A certain excited state of hydrogen atom is known to have a life of  $2.5 \times 10^{-14}s$ . Determine the minimum error with which the energy of the excited state can be measured. [4]

14. Discuss the primary reasons for the strange behaviour associated with nanomaterials. Explain, with a neat sketch, how the idea of tunnelling has been cleverly exploited in a scanning tunnelling microscope. [10]

• 15. a) (i) For a pumping assisted active medium of length,  $L$ , flanked by the mirrors with their reflectivities being  $R_1$  and  $R_2$ , what are the possible losses that may occur? Arrive at an expression for the threshold gain coefficient. [6]

(ii) Distinguish between temporal and spatial coherences. Compute the coherence length of a  $CO_2$  laser whose linewidth is  $8 kHz$ . [4]

OR

15. b) Sketch and explain the different modes of vibration of a  $CO_2$  molecule. Draw a  $CO_2$  laser system and explain its construction and working with the relevant vibrational energy level diagram. [10]

16. List and explain the causes that attenuate the optical signal launched into an optical fiber. What are transparent windows? [10]

17. Explain the working of a p-i-n photodiode. In what way, it is superior to p-n photodiode? Get the expression for responsivity and quantum efficiency. [10]

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