

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

Answer any TEN Questions

(10 X 10 = 100 Marks)

Obtain the wave function for a standing wave on a string of length L with both ends fixed. Derive the formula for eigenfrequencies for the standing wave, and plot the third order of harmonic with properly labelling nodes and antinodes position on the diagram. [5+3
+2]

a) A harmonic wave is propagating from string1 to string2. The mass per unit length for these strings are μ_1 and μ_2 respectively, and the strings are kept under uniform tension T . Write down the transmission and reflection coefficients for the wave in terms of mass per unit length, deduce the conditions for case (i) transmission coefficient is half of the reflection coefficient, and case (ii) velocity of the wave in string2 reduces to half of the wave-velocity in string1. Which property of the wave will remain constant? [2+1+
1+1]

b) For a displacement of a wave on string $y(z,t) = 2 \cos[2\pi 10^6 (t + \frac{z}{2})]$ [All units are in MKS units] [2+2
+1]

Calculate the following:

- (i) Calculate the frequency and wavelength of the wave
- (ii) If the string is under tension 10N, calculate the mass per unit length of the string.

Also, describe the nature of this wave.

Write down Maxwell's equations in differential forms by properly defining the parameters. What is the physical significance of the second Maxwell's equation (Gauss Law for magnetism)? Discuss the incompleteness of Ampere's Law, and how displacement current (or displacement current density) completes it. [4+2
+4]

Explain the time-dependent Schrödinger wave equation. In case the potential is stationary (time-independent) arrive the time-independent Schrödinger wave equation. Then, obtained the time-dependent part of the wave function in this case and write down the full form of the wave function. [2+5+
2+1]

a) What is the de-Broglie hypothesis for the matter wave? By taking an example, demonstrate, why the hypothesis is not relevant to macroscopic objects. [2+3]

b) A particle of mass m and wavefunction $\Psi(x) = b x e^{-ax^2}$ is confined in a region with potential energy $U(x) = 2a^2 \hbar^2 x^2 / m$, where a and b are constants. Deduce the particle energy. [5]

6. Define quantum confinement. Classify the nanomaterials based on quantum confinement with examples and their energy band diagrams. Differentiate nanomaterials from bulk material with at least three main points. [1+3+3+3]

7. A positron of mass, m , is bound within 1D box with potential as: [1+6]

$$V(x) = \begin{cases} 0, & 0 \leq z \leq a \\ \infty, & \text{elsewhere} \end{cases} \quad [3]$$

Stating the reason, start with the appropriate Schrodinger wave equation, evaluate the normalized wavefunction and energy of the state. Calculate the energy of the first excited state and plot corresponding wave function and probability density.

8. Describe the construction with diagrams and discuss the working principle of the CO₂ gas laser with energy level diagram. [5+5]

9. a) Using suitable diagram and equations prove that population inversion is not possible in two-level system. [1+4]

- b) For an emission at a wavelength of 1064 nm, at what temperature both spontaneous and stimulated emission rates are same. [5]

10. Starting with the general construction of optical fiber with suitable diagrams, discuss the light propagation through the optical fiber and derive the expression for acceptance angle. [3+3+4]

11. a) What are the different types of fibers based on refractive index profiles? Point out three major differences between them along with the diagrams. [2+3]

- b) We wish to design a multi-mode step index fiber with V-number, $V = 100$ and numerical aperture, $NA = 0.3$. The refractive index of the core is 1.458, and this fiber will be used in data link with the source of $0.82 \mu m$ light emitting diode (LED). Determine the fiber core radius and refractive index of the cladding. [2+3]

12. With the help of suitable diagrams, describe the basic principles, operation and advantages of PIN Photodiode. Highlight two main differences between PIN and PN photodiodes. [2+2+2+2]

