B/E/TY

Reg. No: 24BCE2037

Final Assessment Test – April 2025

VIT
Vellore Institute of Technology

Course: BPHY101L - Engineering Physics

Class NBR(s): 5257 / 5260 / 5262 / 5264 / 5266 / 5270 / 5271 / 5273 / 5274 / 5276 / 5278 / 5280 / 5283 / 5285 / 5287 / 5289 / 5291 / 5294 / 5298 / 5301 / 5303 / 5305 / 5307 / 5308

Slot: E1+TE1

Time: Three Hours

Max. Marks: 100

- KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE
- DON'T WRITE ANYTHING ON THE QUESTION PAPER

Answer ALL Questions
(10 X 10 = 100 Marks)

1. Derive the expression for the eigenfrequencies of standing waves on a stretched string fixed at both ends. Clearly explain the formation of standing waves and the boundary conditions. Discuss the physical significance of eigenfrequencies, the dependence of frequency on string tension and mass per unit length and sketch the first three normal modes of vibration. **[10]**

2. a) Derive the expression for displacement current using Maxwell's correction to Ampère's Law. Discuss its significance in electromagnetic theory. **[5+5]**
   b) Show how the electric and magnetic fields are related with time and space in an electromagnetic wave propagating in free space. Additionally, sketch the electromagnetic wave, clearly indicating the directions of the electric field, magnetic field, and wave propagation.

3. Explain the properties of a well-behaved wavefunction. Arrive at the mathematical expression for time dependent form of Schrödinger equation. **[10]**

4. Why does the physical property of a material change when its size approaches its de Broglie wavelength? Classify the nanomaterials based on the confinement on excitons with suitable examples. Plot the variation of density of states in each case? **[10]**

5. a) Explain the essential components of a laser with a neat diagram. Describe the role of each component in laser operation. **[5+5]**
   b) Discuss different pumping schemes used in lasers.

6. a) Define the condition for total internal reflection in an optical fiber. Derive a relation between acceptance angle and critical angle. **[5+5]**
   b) Derive the equation for intermodal dispersion in a multimode optical fiber. Explain how intermodal dispersion affects signal transmission.

7. a) Differentiate between direct and indirect band gap semiconductors based on their electronic band structure and optical transition mechanisms. Explain why direct band gap semiconductors are preferred for optoelectronic applications. **[5+5]**
   b) Discuss the effect of forward and reverse bias on charge carrier transfer in optoelectronic devices. Cite one example for a device that operates under forward bias explaining their working principles with necessary diagram.

8. a) In a three-level laser system, the number of atoms in the upper laser energy state (N_2) is 4×10^{16} atoms/m^3, while the number of atoms in the lower laser energy state (N_1) is 1×10^{16} atoms/m^3, Calculate the population inversion density (ΔN). If a laser transition is expected at room temperature between these states, what will be the wavelength of the radiation? [5+5]

b) A laser cavity has a length of 2 cm and consists of mirrors with reflectivity R_1=99% and R_2=95%. If the loss coefficient is 2 m^{-1}, calculate the threshold gain coefficient required for laser action.

9.a) (i) An X-ray photon undergoes Compton scattering at an angle of 60°, and the recoiling electron gains a kinetic energy of 0.2 MeV. Determine the wavelength of the incident photon. [5+5]

(ii) We wish to measure simultaneously the wavelength and position of a photon. Assume that the wavelength measurement gives λ= 6000 Å with an accuracy of one part in a million, that is, $\Delta\lambda/\lambda = 10^{-6}$. What is the minimum uncertainty in the position of the photon?

[OR]

9.b) (i) An electron is confined in a one-dimensional box of width 2 nm. Calculate the first three energy levels of the electrons using the particle in a box model. [5+5]

(ii) A beam of electrons is incident on a barrier 50 eV high and 0.15 nm wide. Find the energy they should have if 0.01 percent of them are to get through the barrier.

10.a) (i) An optical fiber has a core refractive index of 1.50 and a cladding refractive index of 1.45. Find the critical angle and acceptance angle. [5+5]

(ii) A step-index optical fiber has a core diameter of 50 µm, an operating wavelength of 1.3 µm, and the refractive indices of the core and cladding are 1.46 and 1.44, respectively. Find the V parameter of the fiber.

[OR]

10.b) (i) A GaAs LED has an energy bandgap of 1.43 eV. Determine the wavelength of emitted light and identify the region of the electromagnetic spectrum it falls into. [5+5]

(ii) A PIN photodiode has a responsivity of 0.6 A/W at a wavelength of 800 nm. If the incident optical power is 5 mW, calculate the output current.

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