Final Assessment Test – May 2024

VIT
Vellore Institute of Technology

Course: BPHY101L - Engineering Physics

Class NBR(s): 1891 / 1892 / 1893 / 1894 / 1895 / 1896 / 1897 / 1899 / 1900 / 1901 / 1902 / 4393

Slot: D1+TD1

Time: Three Hours

Max. Marks: **100**

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

Answer any TEN Questions

(10 X 10 = 100 Marks)

1. Derive the one dimensional wave equation for a transverse wave traveling on an infinitely long stretched string of mass per unit length $'\rho'$, using appropriate assumptions and a force balance diagram. Deduce an expression for the speed of the wave traveling along the string. [10]

2. a) Why do we hear a 'flick' when a wave traveling along a free-ended string reaches its end? Support your answer by calculating the reflection and transmission coefficients for a free boundary. [5]

   b) A transverse wave on a string is modeled with the wave displacement $y(x,t) = 0.2\ \sin(6.28\,x - 1.57\,t)$, where all physical quantities are in the SI units. Find the i) amplitude, ii) wave number, iii) wavelength, iv) time period, and v) speed of the wave. [5]

3. State the Ampere's law in its original form. With a theoretical argument, show that it fails for non-steady currents. Further, explain Maxwell's contribution to Ampere's law by introducing displacement current density. Verify that the modified Ampere's law satisfies the equation of continuity. [10]

4. Arrive at the Schrödinger's equation in i) time-dependent and ii) time-independent forms for a non-relativistic particle of mass, m, and total energy, E, in one dimension. [10]

5. a) Give a brief note on how Planck's radiation law resolves the drawbacks of the classical theory for blackbody radiation. [5]

   b) The position and momentum of an electron of kinetic energy 0.5 keV are measured simultaneously in a certain experiment. If the position is located within 0.2 nm, what is the percentage uncertainty in the momentum of the electron? [5]

6. A particle of mass m is confined to move between the walls having infinite potential at x = 0 and x = L/2. Obtain the expression for its energy eigenvalues and the normalized wave function. Also, sketch the wavefunction and probability density corresponding to the first two energy levels. [10]

7. Explain why nanomaterials behave differently from their bulk counterparts. How nanomaterials are classified based on quantum confinement? Give an example for each case along with a diagram. [10]

8. Briefly explain the vibrational modes of a CO_2 molecule. Explain the construction and working principle of a CO_2 laser with neat schematics and energy level diagrams. [10]

9. a) Starting from the expression for the round-trip gain of a laser, arrive at an expression for the threshold gain coefficient of a laser. [5]

b) Calculate the temporal coherence lengths l_c of i) a mercury vapor lamp emitting in the green portion of the visible spectrum at a wavelength of 546.1 nm with an emission bandwidth of 0.6 GHz, and ii) a He-Ne laser operating at a wavelength of 632.8 nm with an emission width of 1 MHz. [5]

10. Explain the dispersion of a light signal in an optical fiber using a suitable diagram. Write five striking differences between intramodal and intermodal dispersion. [10]

11. a) Explain the following terms in the context of an optical fiber: (i) Acceptance angle, and ii) V-number. [5]

b) The core diameter of a multimode step index fiber is 60 μm with a relative refractive index difference of 0.013. If the core refractive index is 1.46, determine the number of guided modes when the operating wavelength is 0.75 μm. [5]

12. Classify semiconductor materials using an energy-momentum (or wave vector) (E-k) diagram. Further, with a proper schematic, explain the working principle of a PN photodetector. [10]

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