VIT

Vellore Institute of Technology

Engineering Physics

Class NBR(s): 3706 / 3715 / 3724 / 3731 / 3741 / 3748 / 3759 / 3958

Slot: E1+TE1

Time: Three Hours

Max. Marks: 100

General Instructions :

Make use of the following constant values wherever necessary

(Mass of the electron, $m_e = 9.1 \times 10^{-31}$ kg; Charge of the electron, e = 1.602×10^{-19} C; Planck's constant, h = 6.626×10^{-34} Js; Velocity of light, C= 3×10^{8} ms^{-1}; Boltzmann's constant, $K_B = 1.38 \times 10^{-23} JK^{-1}$)

Answer any TEN Questions

(10 X 10 =10 Marks)

1. Discuss an experiment which confirms both deBroglie hypothesis and wave nature of electron. Substantiate your answer with proper evidence. [10]

2. a) We all long for certainty. In fact, we are wired to find home in a comfortable place, especially when we live in a world so full of uncertainty. Discuss, how Heisenberg solve this problem while measuring physical variables. [5]

   b) A nucleon is confined to a nucleus of radius 5 X 10^{-15}m.Calculate the minimum uncertainty in the momentum of the nucleon. Also calculate the minimum kinetic energy of the nucleon. [5]

   Given, mass of the nucleon = 5 X 10^{-15}kg, Planck's constant 6.623 x10^{-34} Js.

3. If a particle is trapped in a one dimensional potential well what will happen? With necessary theory and applying boundary conditions find out the eigen value and eigen functions for this trapped particle. [10]

4. a) Why carbon plays a major role in carbon nanotube? How, single wall carbon nanotube is classified on the basis of chiral vector? Explain. [5]

   b) You may have noticed how different very small animals are compared to larger ones. Ants have legs that are very skinny compared to their bodies, and they can lift many times its own weight. Elephants on the other side have thick legs and they cannot lift great weights compared to their own mass. [5]

   State the reason and correlate this incident with nanoparticle.

5. Discuss in detail the atomic gas laser, which produces both IR and visible light. State the ways and means by which how can you restrict the IR to obtain the visible light only. [10]

6. a) Can you obtain the laser without metastable state? How the problem of two level laser has been sorted out in three and four level laser? [5]

   b) In a Ga As laser diode, $R_1 = R_2 = 0.34$ for uncoated facets and material absorption α is 10/cm.Calculate the threshold gain K_{th} for a laser diode of length 500 μm and width 10 μm. [5]

7. Write Maxwell's equations for an electromagnetic field and obtain a wave equation for E and B in a homogeneous, isotropic, non conducting medium. [10]

8. a) An electromagnetic wave, propagating with the speed of light in free space is incident normally on a perfect dielectric medium for which the relative permittivity is 5.0. By what factor will the velocity of the wave will get reduced? [5]

   b) Determine the conduction current and displacement current densities in a material having conductivity of 10^{-3} mhos/m and relative permittivity $\varepsilon_r = 2.45$.The electric field in the material is given by E = $4 \times 10^{-6} \sin(9 \times 10^{9} t)$V/m. [5]

9. What do you mean by dispersion? Derive a relation how much intermodal dispersion occurs when the light propagates through the optical fiber. With necessary diagrams state how these problems can be eliminated. [10]

Possession of Mobile Phone in the exam hall even in switched off condition is a malpractice.

10. a) State any five differences between direct bandgap and indirect bandgap semiconductor. [5]

b) In a 100-ns pulse 6×10^6 photons at a wavelength of 1300 nm fall on an InGaAs photodetector. On the average 5.4×10^6 electron-hole pairs are generated. Determine the quantum efficiency. [5]

$\eta = \frac{5.4 \times 10^6}{6 \times 10^6}$

11. State the postulates of Einstein's special theory of relativity and from there deduce the Lorentz transformation for space and time co-ordinates from one inertial frame to another which is in uniform relative motion with respect to the first. [10]

12. a) Explain the phenomena of Time dilation. [5]

b) A rod is lying at rest along the X-axis in frame S. The length of the rod measured by an observer in frame S' moving with a velocity of 0.5C along xx' axes is 0.75 m. What is the length of the rod measured by an observer at rest in the S frame? [5]

$l = l_0\sqrt{1 - \frac{v^2}{c^2}} \Leftrightarrow \Leftrightarrow \Leftrightarrow$

$= 0.75 \times \sqrt{1 - (0.5)^2}$ L

P

$P = \frac{P^2}{2}$

13. By schrodinger's eqn

$$\nabla^2\psi + \frac{8\pi^2 m (E-V)}{h^2}\psi = 0$$

$$\nabla^2\psi = -K^2\psi \quad \left[K = \sqrt{\frac{2mE}{h^2}}\right]$$

Solution is $\psi = A\sin Kx + B\cos Kx$

Applying boundary condition

$B = 0$

$K = \frac{n\pi}{a}$

Hence $\psi = A\sin\frac{n\pi}{a}x$

By normalisation $\int_0^a A^2 \sin^2\frac{n\pi}{a}x\,dx = 1$

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