College of Engineering, Pune

F.Y. B.Tech. (AS–101) Physics-I

Date : 22/11/2011 Timing : 3 h

Academic Year : 2011–12 Max. marks : 50

Instructions:

1. Solve any five questions.

2. Figures to the right indicate full marks.

3. Do not keep mobile phones with you; the handset will be retained by exam cell.

Q.1.a) Assume that a state of particle is described by a wave function of the form $\Psi(x,t) = \psi(x)\varphi(t)$. Show that, $\varphi(t) = A\,e^{-i\omega t}$ (where A and ω are constants). **4**

Q.1.b) Draw neat labeled diagrams showing the energy band structure of semiconductor laser for the following cases: a) without bias b) forward biased above threshold value. **3**

Q.1.c) If $E_1 = \mathrm{i}\,E_x\cos(\omega t - kz)$ and $E_2 = \mathrm{j}\,E_y\cos(\omega t - kz + \theta)$, show that the light wave represented $E_1 + E_2$, where is generally an elliptically polarized wave for arbitrary θ. **3**

Q.2.a) The wave function for a particle in infinite potential well is given as

$$\psi(x) = \sqrt{\frac{1}{5}}\sqrt{\frac{2}{a}}\sin\left(\frac{\pi x}{a}\right) + \sqrt{\frac{4}{5}}\sqrt{\frac{2}{a}}\sin\left(\frac{2\pi x}{a}\right)$$

where $0 \le x \le a$. What is the average value of the energy? What is the probability that the energy measurement will yield the ground state energy? **4**

Q.2.b) In Quantum Mechanics, how is the wave function interpreted? Write the conditions for a valid wave function **4**

Q.2.c) Explain the features of nuclear forces. **2**

Q.3.a) Explain the principle, construction and working of Nd-YAG laser. **4**

Q.3.b) Consider the wavefunction of a particle given by $\psi(x) = Ax\left(1 - \frac{x}{a}\right)$ for $0 < x < a$ and is 0 otherwise. Find A and the probability that the particle would be found in interval $[0.6a, 0.75a]$. **4**

Q.3.c) Write Schrödinger's wave equation for one dimensional harmonic oscillator. What are the energy eigen values? Sketch the energy level diagram. **2**

Q.4.a) Derive the expression constructive and destructive interference of a monochromatic light beam reflected from a thin parallel film of transparent material surrounded by air. **4**

Q.4.b) Based on the total charge, spin, baryon number and strangeness, show that the following baryons are made up of elementary quarks

1. proton (uud), 2. neutron (udd) and 3. π^+ meson $(u\bar{d})$ 3

Q.4.c) Describe the construction of quarter and half wave plate and explain its working principle. 3

Q.5.a) A particle travelling with energy $E > V_0$, has a potential barrier defined as 4

$V = 0 \quad x < 0$

$V = V_0 \quad 0 \leq x \leq a$

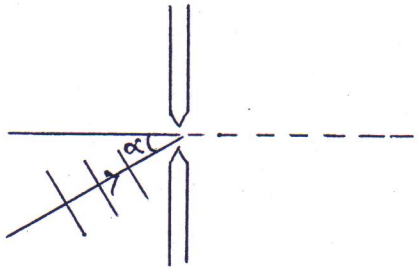
$V = 0 \quad x > a$

Write the Schrödinger's wave equations and its solutions for all the three regions.

Q.5.b) Find the ratio of populations of the two states in a ruby laser that produces a light beam of wavelength 6943Å at 300K 3

Q.5.c) Explain the meson theory of nuclear forces. Show Feynmann diagrams. 3

Q.6.a) A plane wave falls on a single slit at an angle of $\propto$. Find the expression for intensity of Fraunhofer diffraction pattern at an angle θ. Find the condition for maxima and minima of intensity. 4



Q.6.b) Consider a particle of mass m in harmonic oscillator potential with force constant k. Let $\omega = \sqrt{k/m}$. Show that $\psi(x) = e^{-\alpha x^2}$ is an energy eigen function. Find α and energy eigen value in terms of $\hbar$, m and ω. [Hint: If $a + bx + cx^2 = 0$ for all x, then $a = b = c = 0$.] 4

Q.6.c) An excited atom gives up its excess energy by emitting a photon of characteristic frequency. The average period that elapses between the excitation of an atom and the time it radiates is 1×10^{-8} sec. Find the inherent uncertainty in the frequency of the photon. ($\hbar = 1.054 \times 10^{-34}$ J-sec). 2

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