First/Second Semester B.E. Degree Examination, January 2013

Engineering Physics

Time: 3 hrs.
Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing at least two from each part.
2. Answer all objective type questions only in OMR sheet page 5 of the answer booklet.
3. Answer to objective type questions on sheets other than OMR will not be valued.

4. Physical constants: Velocity of light, \( c = 3 \times 10^8 \) m/s, Plank's constant, \( h = 6.625 \times 10^{-34} \) J·s, Electron charge, \( e = 1.602 \times 10^{-19} \) C, Mass of Electron, \( m = 9.11 \times 10^{-31} \) kg, Avogadro number, \( N_A = 6.02 \times 10^{23} \) mol⁻¹, Permittivity of vacuum, \( \varepsilon_0 = 8.85 \times 10^{-12} \) F/m, Boltzmann constant, \( k = 1.38 \times 10^{-23} \) J/K.

**PART - A**

1. a. Choose the correct answers for the following: (04 Marks)
   i) The law which failed to account for shorter wavelength region of black body radiation spectrum is, (A) Wein’s law (B) Rayleigh-Jean’s law (C) Planck’s law (D) Maxwell’s law
   ii) The de-Broglie wavelength of a particle at rest is (A) Zero (B) \( \hbar/p \) (C) \( \hbar/\nu \) (D) \( \hbar \/ m \)
   iii) If group velocity of particle is \( 4.7 \times 10^6 \) m/s then its phase velocity is, (A) \( 6 \times 10^6 \) m/s (B) \( 4.7 \times 10^6 \) m/s (C) \( 9.4 \times 10^6 \) m/s (D) \( 1.91 \times 10^6 \) m/s
   iv) The particle velocity of wave is equal to, (A) group velocity (B) phase velocity (C) velocity of light (D) velocity of sound

b. Describe Davisson and Germer experiment for confirmation of de-Broglie hypothesis. (07 Marks)

c. Derive de-Broglie wavelength using group velocity. (05 Marks)

d. Calculate the de-Broglie wavelength of particle of mass 0.65 MeV/C² has a kinetic energy 80 eV. (04 Marks)

2. a. Choose the correct answers for the following: (04 Marks)
   i) In quantum mechanics the energy operation is represented as:
      A) \( \frac{8\pi^2}{\hbar^2} \) m² s²
      B) \( \frac{\hbar^2}{4\pi^2} \) m² s²
      C) \( \frac{\hbar^2}{2\pi^2} \) m² s²
      D) \( \frac{\hbar^2}{2\pi^2} \) m² s²
   ii) The probability of finding the particle within an element of volume \( dt \) is, (A) zero (B) \( |\psi|^2 \) dt (C) \( |\psi|^4 \) dt (D) \( |\psi|^2 \) dt
   iii) If an electron moves in one dimensional box of length 2 nm, the normalization constant is, (A) 1 (B) \( 2 \) nm⁻¹ (C) \( \sqrt{2} \) nm⁻¹ (D) zero
   iv) The energy of a particle \( E_n \) in one-dimensional potential box of width \( L \) and infinite height is, (A) \( n^2 \) / 8L² (B) \( n^2 \) / 8 mL (C) \( n^2 \) / 8 mL² (D) \( n^2 \) / 8 mL²

b. Set up Schrodinger’s time-independent wave equation. (08 Marks)

c. Using uncertainty principle, prove that free electron does not exist inside the nucleus. (04 Marks)

d. A spectral line of wavelength 4000 A°U has width of \( 8 \times 10^{-5} \) AU. Evaluate the minimum time spent by electrons in upper energy state between excitation and de-excitation processes. (04 Marks)

3. a. Choose the correct answers for the following: (04 Marks)
   i) The free electrons in classical free electron theory are treated as:
      A) rigidly fixed lattice points (B) liquid molecules (C) gas molecules (D) none of these
   ii) The temperature dependence of classical expression for electrical resistivity of a metal is,
      A) \( \rho \alpha T^3 \) (B) \( \rho \alpha T^2 \) (C) \( \rho \alpha 1 / T^2 \) (D) \( \rho \alpha 1 / T \)
   iii) The value of Fermi function in Fermi-level is at \( T \neq 0 \) K, (A) zero (B) 0.5 (C) 0.75 (D) 1
   iv) If \( E_F \) is the Fermi energy at absolute zero, then mean energy \( \overline{E} \) of electron at absolute zero is,
      A) \( \overline{E} = 1.5E_F \) (B) \( \overline{E} = 2 / 3 E_F \) (C) \( \overline{E} = 2 / 5 E_F \) (D) \( \overline{E} = 3 / 5 E_F \)

b. Explain failure of classical free electron theory. (06 Marks)

c. What are the merits of quantum free electron theory? (06 Marks)

d. Calculate the Fermi velocity and mean free path for conduction electrons in silver, given that its Fermi energy is 5.5 eV and relaxation time for electrons is \( 3.83 \times 10^{-14} \) s. (04 Marks)

4. a. Choose the correct answers for the following: (04 Marks)
   i) The electric dipole moment per unit volume is, (A) magnetization (B) dipole moment (C) electric polarization (D) electric susceptibility
   ii) Clausius-Mussoti equation does not holds for, (A) crystalline solids (B) liquids (C) gases (D) vacuum

1 of 2
Contd... Q4 (a)

iii) The relation between B, M and H is,
   A) $H = \mu_0 (M + B)$  
   B) $B = \mu_0 (H + M)$  
   C) $M = \mu_0 (H + B)$  
   D) None of these

iv) Above curie temperature ferromagnetic substance becomes:
   A) anti-ferromagnetic  
   B) strongly ferromagnetic  
   C) paramagnetic  
   D) diamagnetic

b. Discuss polarization mechanism in dielectrics and their frequency dependence. (08 Marks)
c. Differentiate hard and soft magnetic materials with suitable application. (04 Marks)
d. An electric field of $10^4$ V/m is applied on a sample of neon at NTP. Calculate the dipole moment induced in each atom. The dielectric constant of neon is 1.00014. Find the atomic polarizability of neon gas. At NTP 1 kg atom of Ne – gas occupies volume of 22.4 m³. (04 Marks)

PART – B

5 a. Choose the correct answers for the following:
   i) In He-Ne laser the laser emission takes place from,
      A) He-atoms only  
      B) Ne-atoms only  
      C) both He and Ne atoms  
      D) 50% from Helium and 50% from Neon
   ii) Which of the following lead to coherent light:
       A) induced absorption  
       B) spontaneous emission  
       C) Stimulated emission  
       D) None of these
   iii) The pumping method used in semiconductor diode laser is
        A) optical pumping  
        B) electric discharge  
        C) forward bias  
        D) chemical reactions
   iv) The life time of metastable state is about,
        A) $10^{-9}$ sec  
        B) $10^{-13}$ sec  
        C) $10^8$ sec  
        D) $10^9$ sec

b. Obtain an expression for energy density of radiation under equilibrium condition in terms of Einstein coefficient. (08 Marks)
c. What is holography? Explain principle of hologram recording using laser. (04 Marks)
d. A pulsed laser with power 1 mw lasts for 100 ns. If the number of photons emitted per second is $5 \times 10^7$. Calculate the wavelength of laser. (04 Marks)

6 a. Choose the correct answers for the following:
   i) According to BCS theory, the cooper pair is pair of,
      A) Electron-Proton  
      B) Electron-Electron  
      C) Proton-Proton  
      D) Electron-Neutron
   ii) High temperature superconductors bear the crystal structure of,
      A) cubic  
      B) tetragonal  
      C) rhombohedral  
      D) orthorhombic
   iii) The acceptance angle of optical fiber whose RI of core and cladding of 1.55 and 1.50 respectively is,
       A) 32°  
       B) 45°  
       C) 23°  
       D) 15°
   iv) According to Mieoswer effect, material in superconducting state is
       A) paramagnetic  
       B) diamagnetic  
       C) ferromagnetic  
       D) anti-ferromagnetic

b. What is refractive index profile? Describe three types of optical fiber with one application for each type. (08 Marks)
c. Explain working of SQUID with application. (04 Marks)
d. An optical fiber of 600 mts long has input power of 120 mw which emerges out with power of 90 mw. Find attenuation in the fiber. (04 Marks)

7 a. Choose the correct answers for the following:
   i) The lattice parameters $a = b = c$ and $\alpha = \beta = \gamma = 90^\circ$ represent,
      A) cubic  
      B) tetragonal  
      C) rhombohedral  
      D) orthorhombic
   ii) The co-ordination number of rock salt is,
       A) 6  
       B) 8  
       C) 12  
       D) 14
   iii) Which of the following has least packing fraction,
        A) sc  
        B) bcc  
        C) fcc  
        D) diamond
   iv) In a simple cubic lattice $d_{111} : d_{100} : d_{001} =$
       A) $\sqrt{6} : \sqrt{3} : \sqrt{2}$  
       B) $\sqrt{3} : \sqrt{6} : \sqrt{2}$  
       C) $\sqrt{2} : \sqrt{3} : \sqrt{6}$  
       D) $\sqrt{6} : \sqrt{3} : \sqrt{2}$

b. Derive expression for interplanar spacing of crystal in terms of Miller Indices. (07 Marks)
c. What is atomic packing factor? Calculate packing factor for sc and bcc structure. (05 Marks)
d. What is Miller Index of plane making intercepts ratio $3a : 4b$ on x- and y-axis and parallel to z-axis. a, b are primitive vectors? (04 Marks)

8 a. Choose the correct answers for the following:
   i) A bulk material (three dimensions) reduced in one direction is called quantum:
      A) particle  
      B) well  
      C) dot  
      D) wire
   ii) Which belongs to fullerene family?
      A) $C_{60}$  
      B) $C_{70}$  
      C) $C_{120}$  
      D) All
   iii) Velocity of ultrasound through liquid is proportional to,
        A) density  
        B) volume  
        C) bulk modulus  
        D) rigidity modulus
   iv) Ultrasonic waves cannot be transmitted through,
        A) solid  
        B) liquid  
        C) gas  
        D) vacuum

b. What is NDT? Describe the NDT method of detection of flaws in solid using ultrasound. (08 Marks)
c. What are nano materials? Write the structure and applications of carbon nano tubes. (08 Marks)
First/Second Semester B.E. Degree Examination, June/July 2011

Engineering Physics

Time: 3 hrs.
Max. Marks: 100

Note: 1. Answer any FIVE full questions.

2. Physical Constants: 
   - Electron mass: \( m = 9.11 \times 10^{-31} \) kg;
   - Electron Charge: \( e = 1.6 \times 10^{-19} \) C;
   - \( C = 3 \times 10^8 \) m/sec;
   - \( \varepsilon_0 = 8.85 \times 10^{-12} \) F/m;
   - \( h = 6.63 \times 10^{-34} \) JS;
   - \( NA = 6.025 \times 10^{24} / \) K mole.

1. a. Define phase velocity and group velocity. (05 Marks)
   b. Describe Davisson – Germer’s experiment to establish the wave nature of electrons. (10 Marks)
   c. Calculate the de-Broglie wavelength associated with an electron carrying energy 2000 eV. (05 Marks)

2. a. Setup the Schrödinger’s time independent wave equation. (10 Marks)
   b. Distinguish between type – I and type – II superconductors. (06 Marks)
   c. Discuss in brief BCS theory of superconductivity. (04 Marks)

3. a. Explain the density of state. Derive an expression for the number of allowed states per unit volume of a solid. (10 Marks)
   b. Explain the terms: Drift velocity, relaxation time and mean free path for the free electron. (05 Marks)
   c. For a metal having \( 6.5 \times 10^{28} \) conduction electrons per m\(^3\), find the relaxation time of the conduction electron, if the metal resistivity is \( 1.43 \times 10^{-8} \) Ohm-m. (05 Marks)

4. a. Distinguish between hard and soft magnet. (05 Marks)
   b. Derive an expression for the internal field in case of dielectric solids. (10 Marks)
   c. Find the polarization produced in a dielectric medium of relative permittivity 15 in presence of an electric field 500 V/m. (05 Marks)

5. a. Define the terms: spontaneous emission, stimulated emission and population inversion. Explain the construction and working of ruby laser, with an energy level diagram. (10 Marks)
   b. Discuss the recording and reconstruction of an image incase of holography. (05 Marks)
   c. Find the population of two energy levels out of which one corresponds to metastable state, if the wavelength of light emitted at 330 K is 632.8 nm. (05 Marks)

6. a. Obtain an expression for numerical aperture in terms of refractive indices of core and cladding of an optical fiber, with a neat diagram. Calculate the numerical aperture for an optical fiber having refractive indices 1.563 and 1.498 for the core and cladding respectively. (10 Marks)
   b. Explain the phenomenon of production of characteristic X-ray spectrum. (05 Marks)
   c. Derive the expression for Bragg’s law. (05 Marks)

7. a. What are the steps involved in finding miller indices? Derive the expression for interplanar d-spacing of planes in terms of miller indices in a cubic structure. (10 Marks)
   b. Draw the following planes in a cubic unit cell (110), (121), (321). (05 Marks)
   c. The lattice constant of a cubic crystal is 3\( A^\circ \). Find the interplanar d spacing between (111) planes. (05 Marks)

8. a. Explain nanotubes and its applications by giving their physical properties. (07 Marks)
   b. What are composites? Discuss their merits and applications. (08 Marks)
   c. Define quantum bit. Explain. (05 Marks)
Engineering Physics

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3. Answer to objective type questions on sheets other than OMR will not be valued.  
4. **Physical constants:** \( h = 6.625 \times 10^{-34} \text{ J-S}, \) \( C = 3 \times 10^8 \text{ m/s}, \) \( m_e = 9.1 \times 10^{-31} \text{ kg}, \) \( K = 1.38 \times 10^{-23} \text{ J/K}, \) \( \varepsilon_0 = 8.854 \times 10^{-12} \text{ F/m}. \)

**PART – A**

1 a. Choose the correct answers for the following: (04 Marks)
   i) De Broglie wavelength of an electron accelerated through a potential of 60 V is,
      A) 1.850 Å  B) 1.584 Å  C) 1.589 Å  D) 1.570 Å
   ii) The wavelength of maximum intensity is inversely proportional to the absolute temperature of the body emitting radiation. This is called,
      A) Stefan’s law  B) Wien’s displacement law  C) Rayleigh-Jean’s law  D) Plank’s law
   iii) Einstein’s photoelectric equation is given by,
      A) \( E = \phi + (KE)_{\text{max}} \)  B) \( E = \phi - (KE)_{\text{max}} \)  C) \( \phi = E + (KE)_{\text{max}} \)  D) \( (KE)_{\text{max}} = E + \phi \)
   iv) Which of the following relations can be used to determine de Broglie wavelength associated with a particle?
      A) \( \frac{h}{\sqrt{2meV}} \)  B) \( \frac{h}{m\nu} \)  C) \( \frac{h}{\sqrt{2meV}} \)  D) all of these

b. Explain Wein’s law ad Rayleigh-Jean’s law. Mention their drawbacks. (06 Marks)
c. Define phase velocity and group velocity. Derive a relation between the two. (06 Marks)
d. Calculate the wavelength associated with electrons whose sped is 0.01 part of the speed of light. (04 Marks)

2 a. Choose the correct answers for the following: (04 Marks)
   i) For a particle in an infinite potential well in its 1st excited state, the probability of finding the particle at the center of box is,
      A) 0  B) 0.25  C) 0.5  D) 0.1
   ii) The Heisenberg’s Uncertainty relation for position of a particle is given by,
      A) \( \Delta P \Delta x \geq \frac{h}{2} \)  B) \( \Delta P \Delta x \leq \frac{h}{4\pi} \)  C) \( \Delta P \Delta x \geq \frac{h}{4\pi} \)  D) \( \Delta P \Delta x \geq \frac{h}{\pi} \)
   iii) According to Max Born approximation \( |\psi|^2 \) represents,
      A) Particle density  B) Charge density  C) Energy density  D) Probability density
   iv) Schrodinger’s time independent wave equation is applicable for the particle with,
      A) Constant energy  B) Variable energy  C) Only constant potential energy  D) All of these

b. Set up time independent Schrodinger wave equation. (06 Marks)
c. Explain Heisenberg’s Uncertainty principle. Give its physical significance. (06 Marks)
d. An electron is bound in one dimensional infinite well of width 0.12 nm. Find the energy value and de Broglie wavelength in the first excited state. (04 Marks)
3 a. Choose the correct answers for the following:

i) The motor specific heat of a gas at constant volume is given by,
   \( A) \ C_v = \frac{2R}{3} \quad B) \ C_v = \frac{3R}{2} \quad C) \ C_v = \frac{4R}{3} \quad D) \ C_v = \frac{3R}{4} \)

ii) If the Fermi energy of silver is 5.5 eV, the Fermi velocity of conduction electron is,
   \( A) \ 0.98 \times 10^6 \ m/S \quad B) \ 1.39 \times 10^6 \ m/S \quad C) \ 2.46 \times 10^5 \ m/S \quad D) \ None \ these \)

iii) Matthiessen’s rule is given by,
   \( A) \ \rho = \rho_{ph} - \rho_{i} \quad B) \ \rho = \rho_{ph} \quad C) \ \rho = \rho_{ph} + \rho_{i} \quad D) \ \rho = \frac{\rho_{i}}{\rho_{ph}} \)

iv) The value of Fermi distribution function at \( T = 0 \) K is 1, under the condition,
   \( A) \ E = E_{f} \quad B) \ E > E_{f} \quad C) \ E >> E_{f} \quad D) \ E < E_{f} \)

b. Explain failure of classical free electron theory.

c. Explain the probability of occupation of various energy states by electron at \( T = 0 \) K and \( T > 0 \) K on the basis of Fermi factor.

d. Find the temperature at which there is 1.0% probability that a state with an energy 0.5 eV above Fermi energy will be occupied.

4 a. Choose the correct answers for the following:

i) Choose the correct relation,
   \( A) \ E = \epsilon_0 (\epsilon_r - 1)P \quad B) \ P = \epsilon_0 (\epsilon_r - 1)E \quad C) \ \epsilon_r = K - 1 \quad D) \ \epsilon_r = \epsilon_0 (\epsilon_r - 1)E \)

ii) For ferromagnetic substance, the Curie-Weiss law is given by,
   \( A) \ \chi = \frac{C}{T} \quad B) \ \chi = \frac{C}{(T - \theta)} \quad C) \ \chi = \frac{T}{(T - \theta)} \quad D) \ \chi = \frac{C}{(T + \theta)} \)

iii) The only polarization mechanism at frequencies exceeding \( 10^{13} \) Hz is,
   \( A) \ ionic \quad B) \ electronic \quad C) \ orientation \quad D) \ space \ charge \)

iv) Sulphur is an elemental solid dielectric of atomic weight 32.07 and density 2.07 \( \times 10^3 \) kgm\(^{-3}\). The number of atoms per unit volume for Sulphur is,
   \( A) \ 3.89 \times 10^{28} / \text{m}^3 \quad B) \ 3.89 \times 10^{25} / \text{m}^3 \quad C) \ 9.3 \times 10^{24} / \text{m}^3 \quad D) \ None \ of \ these \)

b. Derive an expression for internal field in case of one dimensional array of atoms in dielectric solid.

c. Describe ferroelectricities.

d. If a WaCl crystal is subjected to an electric field of 1000 V/m and the resulting polarization is \( 4.3 \times 10^{-8} \) C/m\(^2\), calculate the static dielectric constant of NaCl.

5 a. Choose the correct answers for the following:

i) If \( n_1 \) is the number density of lower energy \( E_1 \) and \( n_2 \) is the number density of higher energy \( E_2 \), then \( n_2 > n_1 \) is called,
   \( A) \ thick \ population \quad B) \ inverted \ population \quad C) \ normal \ population \quad D) \ no \ population \)

ii) The number of modes of standing waves in the resonant cavity of length 1 m, if He – Ne laser operating at wavelength of 6328 A\( ^\circ \) is,
   \( A) \ 3.16 \times 10^9 \quad B) \ 1.58 \times 10^9 \quad C) \ 3.16 \times 10^8 \quad D) \ None \ of \ these \)

iii) Image is stored on a hologram in the form of,
   \( A) \ interference \ pattern \quad B) \ diffraction \ pattern \quad C) \ photograph \quad D) \ none \ of \ these \)

iv) The relation between Einstein’s coefficients A & B is,
   \( A) \ \frac{8\pi a h^3}{C^3} \quad B) \ \frac{8\pi a h^2 r^3}{C^3} \quad C) \ \frac{8\pi h r^3}{C^3} \quad D) \ \frac{8\pi h r^3}{C^2} \)
5  b. Explain the process of spontaneous and stimulated emission. (06 Marks)
c. Describe the construction and working of semiconductor laser. (06 Marks)
d. A pulse laser has an average power output 1.5 mW per pulse and pulse duration is 20 ns. The number of photon emitted per pulse is estimated to be $1.047 \times 10^8$. Find the wavelength of the emitted laser. (04 Marks)

6  a. Choose the correct answers for the following: (04 Marks)
i) The variation of critical field $H_c$ with temperature $T$ is given by,
A) $H_c = H_0 \left[ 1 - \left( \frac{T}{T_c} \right)^2 \right]$ 
B) $H_c = H_0 \left[ 1 + \left( \frac{T}{T_c} \right)^2 \right]$ 
C) $H_c = H_0 \left[ 1 - \frac{T}{T_c} \right]$ 
D) $H_c = H_0 \left[ 1 + \frac{T}{T_c} \right]$

ii) The quantum of magnetic flux is given by,
A) $\frac{2h}{e}$ 
B) $\frac{h}{2e}$ 
C) $\frac{he}{2}$ 
D) $\frac{2\pi h}{e}$

iii) Fractional index change of optical fiber and refractive index of core are 0.00515 and 1.533 respectively. The cladding refractive index is,
A) 1.492 
B) 1.525 
C) 1.499 
D) 1.511

iv) The attenuation of a fiber – optical cable is expressed in,
A) ohm / km 
B) watt / km 
C) decibel / km 
D) joule / km

b. Describe type – I and type – II superconductors. (06 Marks)
c. What is attenuation? Explain any two factors contributing to the fibre loss. (06 Marks)
d. The angle of acceptance of an optical fibre is 30° when kept in air. Find the angle of acceptance when it is in a medium of refractive index 1.33. (04 Marks)

7  a. Choose the correct answers for the following: (04 Marks)
i) The relation between atomic radius and lattice constant in FCC structure is,
A) $a = 2r$ 
B) $a = 2\sqrt{2}r$ 
C) $a = \frac{\sqrt{3}}{4}r$ 
D) $a = \frac{4r}{\sqrt{3}}$

ii) The crystal with lattices $a = b \neq c$ and angles $\alpha = \beta = \gamma = 90^\circ$ represents,
A) cubic 
B) hexagonal 
C) orthorhombic 
D) tetragonal

iii) The number of atoms present in the unit cell of diamond cubic crystal structure is,
A) 2 
B) 4 
C) 8 
D) 16

iv) Bragg’s law is given by,
A) $2\sin \theta = n\lambda$ 
B) $2d \sin \theta = n\lambda$ 
C) $\frac{2dn}{\sin \theta} = \lambda$ 
D) $2\lambda = \sin \theta$

b. Define (i) Coordination number (ii) Packing factor. Calculate the atomic packing factor for BCC structure. (06 Marks)
c. Sketch the (1 1 2), (1 1 0) and (1 0 0) planes in a simple cubic unit cell. Explain the procedure for obtaining miller indices. (06 Marks)
d. The minimum order of Bragg’s reflection occurs at an angle of 20° in the plane (2 1 2). Find the wavelength of X-rays if lattice constant is 3.615 Å. (04 Marks)
8  a. Choose the correct answers for the following:
   i) In a carbon nanotube the bond between the carbon atom is,
      A) metallic          B) ionic          C) hydrogen          D) covalent
   ii) A constant testing of product without causing any damage is called,
        A) minute testing   B) destructive testing
        C) non-destructive testing   D) random testing
   iii) Ultrasonic waves are sound waves having,
        A) Velocity greater than 330 mS\(^{-1}\)   B) Velocity less than 330 mS\(^{-1}\)
        C) Frequency greater than 20 kHz          D) Frequency less than 20 kHz
   iv) Which of the procedure is not employed to detect the internal flows by a material,
        A) Ultrasonic method   B) Magnetic method
        C) Alpha ray method    D) Dynamic testing

b. Explain carbon nanotubes and its application by giving physical properties.

c. What are ultrasonics? Explain with a diagram a method for measurement of velocity of ultrasonic waves in liquids.