Final Assessment Test – Winter (2024-25) Freshers - May 2025

VIT-AP UNIVERSITY	Final Assessment Test	Duration: 3 Hours
	Maximum Marks: 100	
Course Code:PHY1008	Course Title: Modern Physics	School: SAS
Set No: 01	Exam Type : Closed Book	Session: FN
Date: 20/05/2025	Slot: A2	

Keeping mobile phone/smart watch, even in 'off' position is treated as exam malpractice

General Instructions if any:

Use the following values $h = 6.63 \times 10^{-34}$ J s, $e = 1.6 \times 10^{-19}$ C, $m_e = 9.11 \times 10^{-31}$ kg, $m_n = 1.67 \times 10^{-27}$ kg, $c = 3 \times 10^8$ m/s, 1 eV $= 1.6 \times 10^{-19}$ J, $k_B = 1.38 \times 10^{-23}$ J K^{-1} $= 8.617 \times 10^{-5}$ eV K^{-1}, $\mu_0 = 4\pi \times 10^{-7}$ H/m, Avogadro Number $(N_A) = 6.023 \times 10^{23}$/mol, Bohr Magneton ($\mu_B$ or β) $= 9.27 \times 10^{-24}$ A m^2, wherever required.

1. **"fx series" - non Programmable calculator are permitted : YES**
2. **Reference tables permitted : NO**

Answer any TEN Questions, Each Question Carries 10 Marks (10×10=100 Marks)

Q1 (a) Two coherent waves of equal amplitude A = 5 units interfere at a point. The phase difference between them is $\pi/3$. Calculate the resultant amplitude and intensity at the point of interference.

(b) In a Young's Double Slit Experiment, the slits are separated by a distance d = 0.3 mm, and the screen is placed 1.5 m away from the slits. The experiment is illuminated by monochromatic light of wavelength $\lambda = 600$ nm. Calculate the fringe width (distance between two adjacent bright fringes) on the screen. **(10 M)**

Q2 A thin film of oil (refractive index $n_1 = 1.45$) floats on top of water (refractive index $n_2 = 1.33$). The system is illuminated from above by monochromatic light of wavelength 600 nm in air at normal incidence. What is the minimum non-zero thickness of the oil film such that constructive interference occurs in the reflected light? **(10 M)**

Q3 In a single-slit diffraction experiment, monochromatic light of wavelength $\lambda = 500$ nm is incident normally on a slit of width a = 0.25 mm. The diffraction pattern is observed on a screen placed 2.0 m away from the slit. (a) Calculate the angular positions θ of the first and second minima in the diffraction pattern and (b) Determine the linear distance on the screen from the central maximum to the first minimum. **(10 M)**

Q4 A ground-based optical telescope has an aperture of diameter 1.2 m. It is used to observe two stars emitting light of wavelength $\lambda = 550$ nm, located at a distance of 3.6×10^{16} m (about 3.8 light-years) from Earth. (a) Calculate the angular resolution limit (minimum angular separation θ_{min}) of the telescope and (b) Determine the minimum linear separation between the two stars (in meters) that can be resolved by this telescope at that distance. **(10 M)**

Q5 A particle of mass $m = 9.11\times10^{-31}$ kg (mass of an electron) is confined within a one-dimensional box of width 1.0×10^{-10} m (approximate size of a hydrogen atom). (a) Estimate the minimum uncertainty in the momentum of the electron and (b) Estimate the minimum de Broglie wavelength the electron can have in this region. **(10 M)**

Q6 A wave packet in a dispersive medium is formed by superposition of two waves with slightly different wavelengths. Wave 1 with $\lambda_1 = 1.00$ µm and frequency $f_1 = 3.00\times10^{14}$ Hz. Wave 2 with a wavelength $\lambda_2 = 1.02\ \mu m$ and frequency $f_2 = 2.94\times10^{14}$ Hz. (a) Calculate the phase velocity of each wave and (b) Calculate the group velocity of wave packet. **(10 M)**

Q7 An electron is confined in a 1-D infinite potential well (box) of width 1.0×10^{-10} m. (a) Calculate the energy difference (in eV) between the first and third energy levels and (b) If the electron makes a transition from third excited state to first excited state, what is the wavelength of the emitted photon? **(10 M)**

Q8 A silicon sample is doped with phosphorus (a donor) to a concentration of $N_D = 5\times10^{17}\ cm^{-3}$. The intrinsic carrier concentration of silicon at 300 K is $n_i = 1.5\times10^{10}\ cm^{-3}$. Assuming complete ionization and that the effective density of states in the conduction band is $N_C = 2.8\times10^{19}\ cm^{-3}$, Calculate: (a) The electron concentration 'n' in the conduction band and (b) The Fermi level position E_F relative to the conduction band edge E_C. **(10 M)**

Q9 A silicon sample is studied under two conditions: Case 1: Intrinsic: At 300 K, the intrinsic carrier concentration $n_i = 1.5\times10^{10}\ cm^{-3}$. Case 2: Extrinsic: The same silicon is doped with donor atoms to a concentration $N_D = 1\times10^{16}\ cm^{-3}$. If the electron mobility and hole mobility are $\mu_n = 1350\ cm^2/Vs$ and $\mu_p = 480\ cm^2/Vs$, respectively (a) Calculate the electrical conductivity of intrinsic silicon at 300 K and (b) Calculate the electrical conductivity of the n-type doped silicon. **(10 M)**

Q10 A solar cell under standard test conditions (irradiance = 1000 W/m^2, temperature = 25 °C) has open-circuit voltage 0.6 V, short-circuit current 3.5 A, fill-factor 0.75 and area 100 cm^2. (a) Calculate the maximum output power of the solar cell, (b) Calculate the input power received by the cell and (c) Determine the efficiency of the solar cell. **(10 M)**

Q11 A body-centered cubic (BCC) iron crystal contains two atoms per unit cell. The density of iron is $\rho = 7.87\ g/cm^3$, and its atomic weight is 55.85 g/mol. Assume each iron atom contributes a magnetic moment of 2.22 μ_B (Bohr magnetons). (a) Calculate the number of atoms per unit volume (in atoms/m^3) and (b) Calculate the saturation magnetization Ms in units of A/m. **(10 M)**

Q12 A paramagnetic material follows the Curie-Weiss law, which relates magnetic susceptibility χ to temperature T as: $\chi = C/(T-\theta)$, where C is the Curie constant and θ is the Weiss constant (Curie temperature). For a sample of material with C = 0.9 K, and θ = 20 K. (a) Plot the variation of magnetic susceptibility χ with temperature in the range T = 25K to 100 K. (Assume a step of 25 K) and (b) Determine the temperature at which the susceptibility χ becomes 0.018. **(10 M)**