Total No. of Questions – [3] Total No. of Printed Pages: [3]

G.R. No.		PAPER CODE	U111-204A (REG)

May 2022 (INSEM+ ENDSEM) EXAM

F.Y. B. TECH. (SEMESTER - II)

COURSE NAME: ENGINEERING PHYSICS

COURSE CODE: ES10204A

(PATTERN 2020)

Time: [2Hrs] [Max. Marks: 60]

Instructions to candidates:

1) **Figures to the right indicate full marks.**
2) **Use of scientific calculator is allowed**
3) **Use suitable data wherever required**

Q.1 **Solve the following**

i) A spring-mass system, has mass m, spring constant k and damping coefficient c. A second spring-mass system has twice the mass (2m), twice the spring constant (2k) but the same damping coefficient (c). Which of the following statements is true? [2]

a) both systems have the same natural frequency and same damping ratio
b) second system has larger natural frequency and same damping ratio
c) second system has the same natural frequency and smaller damping ratio
d) second system has the same natural frequency and larger damping ratio

ii) A spring-mass system with mass m and spring constant k, is provided viscous damping by air in one experiment and by water in the second experiment. Which of the following statements is true? [2]

a) damping of oscillations will occur faster in the second experiment with water
b) the damped frequency in the second experiment with water will be smaller than that in the first experiment with air
c) the natural frequency in both the experiments will be the same
d) all the options

iii) The displacement of a simple harmonic motion is represented by the equation [2]

$$u(t) = (7.4cm)\sin(2.95t - 0.78)$$

What is its displacement at a time of 3.4 s?
a) 6.91 cm b) 1.29 cm c) -4.77 cm d) -0.64 cm

iv) A mass of 1kg is suspended from a spring and the spring is found to extend by 1cm. If this mass-spring system is set into oscillations, the damped time period is measured to be 0.202s, then what is the value of damping ratio ζ? [2]

a) 0.113 b) 0.118 c) 0.047 d) 0.094

v) A sack of 100kgs of wheat is hung from a spring with a spring constant k=100N/m and is being oscillated by an external harmonic force with an angular frequency ω=1.4142 rad/s. There is a hole in the sack and the wheat is flowing out of the sack at a rate of 1kg/min, thus reducing the mass continuously. After how many minutes will there be a resonance. Assume that the damping ratio is negligible. [2]

a) 10min b) 25min c) 50min d) 75min

vi) A damped forced oscillation system has a natural angular frequency of ω_n and the external exciting force has an angular frequency of ω. In the initial phase of oscillations (before the steady state), the system oscillates with an angular frequency of [2]

a) ω_n b) ω c) both ω_n and ω simultaneously d) none of the two

vii) For a forced damped oscillator, if the damping factor is doubled then the deformation response factor at $\omega << \omega_n$ ________ the original value [2]

a) becomes half of b) becomes twice of c) becomes one-fourth of d) does not change from

viii) A mass spring system with mass m=1kg and spring constant k=100 N/m and a damping factor ζ=0.3 is subjected to a sinusoidal external force with an angular frequency ω. What is the value of ω at which resonance will occur? [2]

a) 9.055 rad/s b) 9.539 rad/s c) 11.043 rad/s d) 10.483 rad/s

ix) For Germanium, the effective density of states for the conduction band $N_c = 4.7 \times 10^{17} cm^{-3}$ and that for the valence band is $N_v = 9 \times 10^{18} cm^{-3}$ at T = 300K. What is the intrinsic charge carrier density for Ge if its band gap is 1.424 eV? [2]

a) $9.7 \times 10^{5} cm^{-3}$ b) $1.9 \times 10^{13} cm^{-3}$ c) $2.0 \times 10^{10} cm^{-3}$ d) $2.1 \times 10^{6} cm^{-3}$

x) Lattice spacing of Ge is $a = 5.6575Å$. Calculate the value of the deBroglie wavelength λ of the electrons in the solid for which the first band gap will appear. [2]

a) $1.77 \times 10^{-9} m$ b) $11.315 \times 10^{-10} m$ c) $8.55 \times 10^{-10} m$ d) $11.14 \times 10^{9} m$

xi) Germanium has an intrinsic charge carrier density of $2 \times 10^{13} cm^{-3}$. If it is doped with pentavalent impurity density of $N_D = 5.4 \times 10^{15} cm^{-3}$, then what is the minority charge carrier concentration?

a) $3.7 \times 10^{10} cm^{-3}$ b) $7.4 \times 10^{10} cm^{-3}$ c) $9.7 \times 10^{9} cm^{-3}$ d) $3.9 \times 10^{11} cm^{-3}$

xii) For an intrinsic semiconductor, the Fermi energy is given by $E_{Fi} = \frac{E_c + E_v}{2} + \frac{kT}{2} ln\left(\frac{N_v}{N_c}\right)$, where, $N_c = 2\left[\frac{m_e^* kT}{2\pi\hbar^2}\right]^{3/2}$ and $N_v = 2\left[\frac{m_h^* kT}{2\pi\hbar^2}\right]^{3/2}$. The values of the effective masses for Si are $m_h^* = 0.8 m_0$ and $m_e^* = 1.18 m_0$, where m_0 is the rest mass of an electron. At 300K, the Fermi energy deviates from the center of the band gap by [2]

a) 0.1281 eV b) -0.0936 eV c) 0.0392 eV d) -0.0075 eV

xiii) For intrinsic GaAs with a band gap of 1.424eV, the probability of absence of an electron at the top of the valence band is [2]

a) 1.03×10^{-12} b) 9.51×10^{-5} c) 0.0098 d) 0.05

xiv) If the current flowing through a p-n junction diode is -1nA for a reverse voltage of -20V at a temperature of 300K, then the value of forward current at an applied voltage of 0.35V is: [2]
a) 0.779 mA b) 3.861mA c) 1.739mA d) 381μA

xv) Germanium has an intrinsic charge carrier density of $2 \times 10^{13} cm^{-3}$. If it is doped with trivalent impurity density of $N_A = 1.9 \times 10^{17} cm^{-3}$, then what is the value of E_F-E_v if the band gap is 0.661 eV? [2]
a) 0.2363 eV b) 0.1947 eV c) 0.0942 eV d) 0.0661 eV

Q2 **Solve any three out of four**

a) With the help of a neat diagram, derive the expression for RMS material dispersion of an optical fiber. [5]

b) With the help of neat diagrams analyze and compare the pulse broadening due to inter-modal dispersion in multi-mode step refractive index, multi-mode graded refractive index and single mode step refractive index optical fibres. [5]

c) An optical fibre has a core refractive index n_1=1.5 and a fractional refractive index Δ=0.001. What are the values of maximum acceptance angle θ_0, angle of refraction θ_R and critical angle ϕ_c? [5]

d) A 10km long glass optical fibre is used to transmit data which has an attenuation coefficient of 2dB/km. If an optical signal of 5mW is launched into the fibre, what is the output power? What is the total attenuation in dB? [5]

Q.3 **Solve any three out of four**

a) Draw a neat diagram and explain the concept of stimulated emission of light. Explain in detail the importance of metastable state and pumping in sustenance of stimulated emission. [5]

b. Discuss the applications of CO_2, Nd:YAG and Fibre lasers in the mechanical industry with emphasis on the specific property of laser that is used in the application. [5]

c) A fibre laser has a full width of the gain curve of 10Å at 15500Å. If the length of the optical cavity of the laser is 100cm, and the refractive index of the optical fibre is 1.5, then what is the [5]
1) mode number m
2) peak frequency
3) width of the gain curve in terms of frequency
4) mode separation frequency ν_{ms}
5) how many modes are allowed in the width of the gain curve

d) If active medium of a laser has an absorption coefficient for its wavelength as α=100cm^{-1}, length of optical cavity L = 10cm, reflectivity of the two mirrors of the optical cavity R_1=0.98 and R_2=0.80, then what is the threshold optical gain? How is the optical gain controlled? [5]