B Sc Eng. IPE/ME/2nd Semester

Date: 24 September 2025
Time: Morning

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF NATURAL SCIENCES

Semester Final Examination — **Summer Semester: 2023-2024**
Course Number: PHY 4213 — **Full Marks: 120**
Course Title: Waves and Oscillations, Geometrical Optics and Wave mechanics — **Time: 2 Hours**

Answer all **4 (Four)** questions. Figures in the right margin indicate full marks of questions whereas corresponding CO and PO are written within parentheses

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1. (a) Define reverberation time and absorption coefficient. Briefly explain the methods of controlling the reverberation time for a good auditorium. (3+3) (CO1) (PO1)

(b) State the differences between Maxwell-Boltzmann statistics, Bose-Einstein statistics, and Fermi-Dirac statistics. (6) (CO1) (PO1)

(c) Describe the mechanical and optical parts of a compound microscope. Mention some important applications of a compound microscope. (4+2) (CO1) (PO1)

2. (a) Formulate the Bose-Einstein distribution function by using the micro-canonical ensemble method (where the total number of bosons and total amount of energy are fixed), which can be expressed as $n_i = \frac{g_i}{(e^{\alpha+\beta E_i}-1)}$, where n_i is the number of bosons in the energy level with energy E_i with degeneracy g_i. (20) (CO2) (PO2)

(b) Using the ray diagram for the optical parts, describe that the total magnification of a compound microscope is given by the combination of magnifications by eye piece (m_e) and objective lens (m_o). Also, formulate that the value of the combined magnification for near point image is, $m = -\frac{v_0}{u_0}\left(1+\frac{D}{f_e}\right)$ while that for normal vision is, $m = -\frac{v_0}{u_0}\times\frac{D}{f_e}$. Here, the symbols have their usual meanings. (20) (CO2) (PO2)

(c) (i) Formulate the equation of growth and decay of sound energy. Using the equation of decay of sound energy, express Sabine's formula for the reverberation time, which can be expressed as $T = \frac{0.163V}{A}$, where T is the reverberation time, V is the volume of the enclosure, and A is the effective absorbing area. (10+10) (CO2) (PO2)

(ii) A microscopic particle of mass m is moving along x-direction. Formulate the expression of time dependent Schrodinger equation that describes the motion of the particle.

3. (a) A plane progressive wave travelling on a very long string is described by the wave equation $y(x,t) = 3\times10^{-2}sin\left(0.4\pi x - 24\pi t - \frac{\pi}{6}\right)$, where x and y are expressed in meters and t in seconds. The string has a linear density, $\rho = 0.025\ kg/m$. Calculate: (i) the amplitude, (ii) the wavelength, (iii) the frequency (f) and the period (T) for the oscillation on the string, (iv) the phase velocity, (v) the transverse displacement of the wave at $x = 10\ m$ when $t = 0.125\ sec$, (vi) the maximum speed of a particle on the string, and (vii) the tension in the string. [Use the general wave equation $y(x,t) = Asin(kx - \omega t + \phi)$ for a travelling wave]. (7) (CO3) (PO2)

(b) Superposition of two waves of almost equal frequencies is given by the equation $y(x,t) = 2Acos\left[\frac{(\omega_1-\omega_2)t}{2} - \frac{(k_1-k_2)x}{2}\right]cos\left[\frac{(\omega_1+\omega_2)t}{2} - \frac{(k_1+k_2)x}{2}\right]$. (7) (CO3) (PO2)

(i) Derive the equation of group velocity, which is expressed as $v_g = \frac{d\omega}{dk} = v_p - \lambda\left(\frac{dv_p}{d\lambda}\right)$.

(ii) The velocity of ripples on a liquid surface is $v_p = \sqrt{\frac{2\pi S}{\lambda\rho}}$, where S is the surface tension and ρ is density of the liquid. Find the group velocity of the ripples.

(c) A classroom of the Islamic University of Technology has the dimensions of a length of 10.5 m, a width of 5.5 m, and a height of 4.0 m. Calculate the reverberation time when (i) all of the surfaces have the same average absorption coefficient of 0.10 and (ii) the various surfaces have the absorption coefficients given in the table below. (7) (CO3) (PO2)

Surface	Absorption coefficient
Wall	0.65
Floor	0.30
Ceiling	0.70

4. (a) If the distance between two objects is 0.5λ, their images are just separated for distinct vision by a compound microscope. Determine the resolving power of the microscope when you use sodium light (λ=589.8 nm) for viewing. Determine its limit of resolution. (7) (CO3) (PO2)

(b) Write the physical significance of ψ and $|\psi|^2$. How do you normalize a wave function? (7) (CO3) (PO2)

(c) The wavefunction associated with particle is given by $\psi = Ae^{ikx}$. Calculate the momentum of the particle. (7) (CO3) (PO2)