

L-1/T-2/IPE

Date: 06/09/2025

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2023-2024

Sub: **PHY 163** (Waves and Oscillations, Physical Optics and Wave Mechanics)

Full Marks: 210

Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

**SECTION - A**

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Differentiate between coherent and incoherent waves. What is interference of light? (8)  
(b) Derive the conditions of bright and dark fringes for both reflected light from and transmitted light through the surface of a thin film. (20)  
(c) A beam of parallel rays falls on a transparent film of thickness  $39 \mu\text{m}$  and refractive index  $1.55$  at an incident angle  $60^\circ$ . On the examination of the film by reflected light, a dark fringe corresponding to wavelength  $589.3 \text{ nm}$  is found. Calculate the order of interference of the dark fringe. (7)
2. (a) What is diffraction of light? Distinguish between Fresnel and Fraunhofer diffraction of light. (10)  
(b) Derive an expression for the intensity distribution on a screen due to Fraunhofer type of diffraction at double slits illuminated normally by monochromatic light. Discuss what do you understand by missing order in the diffraction pattern of double slits? (20)  
(c) What is the highest order spectrum which may be seen with monochromatic light of wavelength  $589.3 \text{ nm}$  by means of a diffraction grating having  $15000 \text{ lines/inch}$ ? (5)
3. (a) Define polarization of light. Discuss with a schematic diagram how a tourmaline crystal can polarize the unpolarized light. (13)  
(b) State and explain Brewster's law and Malus' law for polarization of light. (15)  
(c) Prove that two plane polarized light waves of equal amplitude, their planes of vibration being at right angles to each other, cannot produce interference effects. (7)
4. (a) What is reverberation, and how does reverberation time affect the acoustic quality of a room? What are the key acoustic requirements of a good auditorium? (10)  
(b) Why is there no net transfer of energy in a stationary wave? Support your answer with both physical reasoning and mathematical explanation. (18)

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**PHY 163/IPE**

**Contd.... for Q. No. 4**

(c) The dispersion equation of a waveguide, which relates the wavenumber  $k$  to the frequency  $\omega$ , is  $k = \frac{1}{c} \sqrt{\omega^2 - \omega_0^2}$ , where the speed of light  $c = 3 \times 10^8$  m/s, and  $\omega_0$  is constant. If the group velocity is  $4 \times 10^8$  m/s, then find the phase velocity. (7)

**SECTION – B**

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) What are Lissajous' figures? On what factors do they depend? Describe how these figures are useful in the laboratory. (7)

(b) Write the differential equation of a damped harmonic oscillator subjected to a resistive force that is proportional to the first power of its velocity. Solve it to obtain an expression for the displacement in the case of damped oscillatory motion. (20)

(c) For the damped oscillator shown in Fig. for Q. No. 5(c), the mass of the block is 200 g, the spring constant  $k = 80$  Nm<sup>-1</sup> and the damping constant  $b = 40$  gs<sup>-1</sup>. Calculate (i) the period of oscillation, (ii) the time taken for its amplitude of vibrations to drop to half of its initial value, and (iii) the time for the mechanical energy to drop to half its initial value. (8)

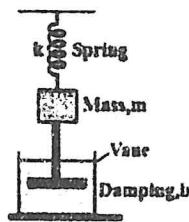


Fig. for Q. No. 5(c)

6. (a) Define wave motion and describe the different types of waves with suitable examples. (7)

(b) A plane progressive wave is propagating through a fluid medium of density  $\rho$ . Deduce the expressions for energy density and intensity of the plane progressive wave. (20)

(c) A progressive wave is represented by the equation

$y = 0.25 \sin \frac{\pi}{65} (68000t - 2x)$  cm. If the wave is travelling through a medium of density 0.00129 g/cm<sup>3</sup>, find the flow of energy across a square centimeter per second. (8)

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**PHY 163/IPE**

7. (a) What does physically mean that particles are indistinguishable? Explain the principle of indistinguishability using symmetric and antisymmetric wavefunctions. (5)
- (b) Deduce the Maxwell-Boltzmann distribution function in micro-canonical ensemble. (20)
- (c) Calculate the most probable, the mean, and the root mean square absolute velocity in the classical perfect gas using the following probability velocity distribution: (10)

$$f(v) = 4\pi \left( \frac{m}{2\pi kT} \right)^{\frac{3}{2}} v^2 e^{-\frac{mv^2}{2kT}}$$

where the symbols have their usual meaning.

8. (a) Write down the postulates of quantum mechanics. (5)
- (b) Consider the one-dimensional infinite square well as: (20)

$$V(x) = \begin{cases} 0 & \text{for } 0 < x < a \\ \infty & \text{Otherwise} \end{cases}$$

Show that the wave function for the  $n$ th stationary state can be written as:

$$\psi_n(x) = \sqrt{\frac{2}{a}} \sin\left(\frac{n\pi}{a}x\right)$$

Finally, draw the energy level, wave functions, and their corresponding probability densities.

- (c) Calculate  $\langle x \rangle$ ,  $\langle p \rangle$  for the  $n$ th stationary state wave function of the infinite square well. Check that the uncertainty principle is satisfied. (10)

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