BANGLADESH UNIVERSITY OF PROFESSIONALS
Military Institute of Science and Technology
B.Sc. in Environmental, Water Resources and Coastal Engineering (EWCE),
Term Final (Fall) Examination 2023: Dec 2023- Feb 2024

Student Group: 0<Earned Credit Hours ≤ 36

Subject: PHY-101, Waves and Oscillation, Optics and Modern Physics

Time: 3.00 hours **Full Marks: 180**

INSTRUCTIONS:

a. Use **SEPARATE** answer scripts for each section.
b. **Question-1** in **Section-A** and **Question-5** in **Section-B** are compulsory
c. Answer any other **TWO** rest of the **THREE** questions from each section.
d. Figures in the margin indicate full **marks**.
e. Assume reasonable data if necessary.
f. **Symbols** and **abbreviations** used have their usual meanings.

SECTION-A

Question 1 (Compulsory)

a. Define simple harmonic motion with example and write down its characteristics. **12**

b. Show that the average kinetic and potential energy of a body executing simple harmonic motion (SHM) is half of its total mechanical energy. **10**

c. A particle performing SHM has a period of 8 s and amplitude of 8 cm. The particle starts from the mean position and moves towards the positive extremity. Find its (i) displacement, (ii) velocity and (iii) acceleration after 1.5 s. **08**

Question 2

a. What are (i) damped oscillation, and (ii) forced oscillation? Discuss the amplitude vs driving frequency graph in a forced oscillation and explain resonance. **09**

b. Derive the differential equation of a damped mass-spring system and hence find the general solution. Show that the displacement equation for under damped case is given by: **12**

$$x(t) = x_0 e^{-\beta t} \sin(\omega t + \varphi).$$

c. The recoil energy of a rocket launcher of mass 4500 kg is absorbed in a spring. At the end of the recoil, a damping dashpot is arranged in such a way that the launcher returns to the firing position without any oscillation (critical damping). The launcher recoils 3 m with an initial speed of 10 ms^{-1}. Find: (i) the recoil's spring constant, (ii) the dashpot's coefficient of critical damping and (iii) the displacement equation of the launcher. **09**

Question 3

a. What are node and antinode of stationary wave? Derive the expressions for the position of nodes and antinodes in the stationary waves. **10**

b. Find an expression for total energy density of a plane progressive wave and show that the total energy density is conserved in time. **12**

c. A sinusoidal wave traveling along a string is given by, **08**

$$y(x,t) = 0.00327 \sin(72.1x - 2.72t),$$

in which the numerical constants are in S.I. units. Find: (i) wavelength, (ii) frequency, and (iii) speed of the wave.

Question 4

a. What is mas defect? Discuss the classification of Beta (β)-decay with examples. **10**

b. Find the expression of half-life and mean-life in terms of radioactive decay constant. **12**

c. The radioactive decay constant is 0.048 $days^{-1}$. Calculate: **08**
(i) half-life of the radioactive substance and
(ii) the time for $\frac{3}{4}$ of the original number of atoms to remain unchanged.

SECTION-B

Question 5 (Compulsory)

a. Define inertial frame of reference. Derive the equations for Lorentz transformation. **10**

b. Show that the relationship between relativistic energy and momentum can be written as: **12**

$$E = \sqrt{m_0^2c^4 + p^2c^2}.$$

c. The rest length of a rod is 6 m. What would be its length for an observer if it be moving relative to him in a direction parallel to its own length, (i) with velocity 0.5c, (ii) moving with velocity c, and (iii) what would be its length for an observer who himself is moving along with it with the same velocity? **08**

Question 6

a. What is work function? Deduce Einstein's equation for photoelectric effect. **10**

b. Write down the de-Broglie's hypothesis of matter wave. Find expressions for the radius and total energy of atom on the basis of Bohr's atomic model. **14**

c.. A light source of wavelength λ illuminates a metal and ejects photoelectrons with a maximum kinetic energy of 4 eV. A second light source with half the wavelength of the first ejects photoelectrons with a maximum kinetic energy of 9 eV. Calculate the work function of the metal. **06**

Question 7

a. Define cardinal points and equivalent focal length of a lens. Deduce an expression for the equivalent focal length of two thin lenses separated by a finite distance. **10**

b. Derive the expression for intensity due to Young's double slit experiment and hence find the conditions of maxima and minima of intensity of light. **14**

c. Two straight and narrow parallel slits 2 mm apart are illuminated by monochromatic light. Fringes are formed on the screen held at a distance of 150 cm. Separation of consecutive fringes are 0.50 mm apart. What is the frequency of light? **06**

Question 8

a. What is Fraunhofer's class diffraction of light? Discuss the Fraunhofer diffraction of light due to single slit. Hence deduce the expressions for maxima and minima. **14**

b. What is polarization of light? State and explain Brewster's law of polarization of light. **10**

c. Intensity of light through a polarizer and analyzer is maximum when their principal planes are parallel. Through what angle the analyzer must be rotated so that the intensity gets reduced to $\frac{1}{5}$ of the maximum value. **06**