BPHE-102/PHE-02

ASSIGNMENT BOOKLET
Bachelor's Degree Programme (B.Sc.)

OSCILLATIONS AND WAVES

Valid from January 1, 2023 to December 31, 2023

It is compulsory to submit the Assignment before filling up the Term-End Examination Form.

Please Note

- **You can take electives (56 to 64 credits) from a minimum of TWO and a maximum of FOUR science disciplines, viz. Physics, Chemistry, Life Sciences and Mathematics.**
- **You can opt for elective courses worth a MINIMUM OF 8 CREDITS and a MAXIMUM OF 48 CREDITS from any of these four disciplines.**
- **At least 25% of the total credits that you register for in the elective courses from Life Sciences, Chemistry and Physics disciplines must be from the laboratory courses. For example, if you opt for a total of 64 credits of electives in these 3 disciplines, at least 16 credits should be from lab courses.**
- **You cannot appear in the Term-End Examination of any course without registering for that course. Otherwise, your result will not be declared and the onus will be squarely on you.**

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THE PEOPLE'S UNIVERSITY

School of Sciences
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Maidan Garhi, New Delhi-110068

2023

Dear Student,

We hope you are familiar with the system of evaluation to be followed for the Bachelor's Degree Programme. At this stage you may probably like to re-read the section on assignments in the Programme Guide for Elective Courses that we sent you after your enrolment. A weightage of 30 percent, as you are aware, has been earmarked for continuous evaluation which consists of **one tutor-marked assignment** for this 2-credit course. **Submit your assignments at your study centre.**

Instructions for Formatting Your Assignments

Before attempting the assignment, please read the following instructions carefully:

1) On top of the first page of your TMA answer sheet, please write the details exactly in the following format:

ENROLMENT NO.:……………………………………………

NAME :……………………………………………

ADDRESS :……………………………………………

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COURSE CODE: …………………………….

COURSE TITLE : …………………………….

ASSIGNMENT NO. ………………………….…

STUDY CENTRE: ……………………..….. DATE:.……………………………………...

PLEASE FOLLOW THE ABOVE FORMAT STRICTLY TO FACILITATE EVALUATION AND TO AVOID DELAY.

2) Use only foolscap size writing paper (but not of very thin variety) for writing your answers.
3) Leave 4 cm margin on the left, top and bottom of your answer sheet.
4) Your answers should be precise and in your own words. Do not copy answers from study material.
5) While solving problems, clearly indicate the question number along with the part being solved. Write units at each step of your calculations as done in the text because marks will be deducted for such mistakes. Take care of significant digits in your work. Recheck your work before submitting it.
6) **This assignment will remain valid from January 1, 2023 to December 31, 2023**. However, you are advised to submit it within **12 weeks** of receiving this booklet to accomplish its purpose as a teaching-tool.

Answer sheets received after the due date shall not be accepted.

We strongly feel that you should retain a copy of your assignment response to avoid any unforeseen situation and append, if possible, a photocopy of this booklet with your response. If you have any problems or queries related to the course, you can write to us on the e-mail **srjha@ignou.ac.in.**

We wish you good luck.

Tutor Marked Assignment
OSCILLATIONS AND WAVES

Course Code: BPHE-102/PHE-02
Assignment Code: BPHE-102/PHE-02/TMA/2023
Max. Marks: 100

Note: Attempt all questions. Symbols have their usual meanings. The marks for each question are indicated against it.

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1. a) i) A satellite revolves in a circular orbit around the earth at a certain height (h) above it. Suppose that $h << R$, the radius of the earth. Calculate the time period of revolution of the satellite. (5)

   ii) Derive expressions for average energy of a body executing SHM. (5)

   b) A spring mass system is characterized by $k = 5\ \text{Nm}^{-1}$ and $m = 1.5$ kg. The system is oscillating with amplitude of 0.20 m. i) Calculate the angular frequency of oscillation. ii) Obtain an expression for the velocity of the block as a function of displacement and calculate its value at $x = 0.2$ m. iii) Also calculate energy of the spring-mass system. (2+4+4)

   c) Establish the equation of motion of a damped oscillator. Solve it for a weakly damped oscillator and discuss the significance of the results. (3+5+2)

   d) The steady-state amplitude of a weakly damped forced oscillator is given by

$$a(\omega) = \frac{f_0}{[(\omega_0^2 - \omega^2)^2 + 4b^2\omega^2]^{1/2}}$$

   Depict it as a function of frequency and obtain expression for resonance frequency. Also obtain expression for peak value of steady-state amplitude. (5+2+3)

   e) Consider N identical masses connected through identical springs of force constant k. The free ends of the coupled system are rigidly fixed at $x = 0$ and $x = l$. The masses are made to execute longitudinal oscillations on a frictionless table.

   i) Depict the equilibrium as well as instantaneous configurations.

   ii) Write down their equations of motion, decouple them and obtain frequencies of normal modes. (2+2+4+2)

2. a) i) A sound wave of frequency 166 Hz travels with a speed 332 ms^{-1} along positive x-axis in air. Each point of the medium moves up and down through 5.0 mm. Write down the equation of the wave and calculate the (i) wavelength, and (ii) wave number. How far are points which differ in phase by 45°? (2+3)

   ii) Derive expression for average rate at which energy is transported by a progressive wave propagating in a medium. (5)

b) i) Explain Doppler effect and obtain expression for apparent frequency when the source as well as the listener are in motion. (5)

ii) A train moving with speed 72 km h^{-1} emits a whistle of frequency 600 Hz. A person is standing stationary on the platform. Calculate the frequency heard by the person if the train (i) approaches and (ii) recedes away from the listener. (5)

c) i) All particles between any two consecutive nodes in a stationary wave are in phase. Show that they are in opposite phase with the particles between the next pair of nodes. (5)

ii) The equation of a stationary wave is given by

$$y(x,t) = 2\sin \pi x \cos 100\pi t,$$

where x and y are in meters and t is in seconds. Calculate the amplitude, wavelength and frequency of component waves whose superposition generated stationary waves. (5)

d) Calculate acoustic impedance of air and water at STP using the data $\rho_{air} = 1.29\,\text{kg m}^{-3}$, $v_{air} = 332\,\text{ms}^{-1}$, $\rho_{water} = 10^3\,\text{kg m}^{-3}$ and $v_{water} = 1500\,\text{ms}^{-1}$. Derive the formula used. (3+7)

e) i) Show that only odd harmonics can be generated in a closed-end organ pipe. (5)

ii) For gravity waves, the phase velocity is given by

$$v_p = C\lambda^{1/2}$$

Show that group velocity for these waves is half of their phase velocity. (5)

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