PHE-09

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

OPTICS

Valid from January 1, 2021 to December 31, 2021

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
Indira Gandhi National Open University
Maidan Garhi, New Delhi-110068

2021

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 per cent, as you are aware, has been earmarked for continuous evaluation which consists of **one tutor-marked assignment** for this 4-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, 2021 to December 31, 2021**. 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.

We wish you good luck.

Tutor Marked Assignment
OPTICS

Course Code: PHE-09
Assignment Code: PHE-09/TMA/2021
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. i) State and explain Fermat's principle. Using this principle, derive Snell's law of refraction. (4+6)

   ii) A beam of light is propagating in vacuum and its frequency is constant. Show that the average energy carried by it per unit area is proportional to the associated electric field vector. (5)

   iii) Two plane polarised light waves are propagating along the positive z-direction such that their electric field vectors are mutually perpendicular. These waves are superposed. Obtain the condition under which the resultant wave will be circularly polarised. (5)

   iv) For a crystal, the refractive index n_o for the o-ray is 1.5442 for light of wavelength 6×10^{-7} m. The least thickness of the crystal used as a quarter wave plate is found to be 1.65×10^{-5} m. Determine the refractive index n_e for the e-ray in this crystal. (5)

2. i) The wavelength of light used in Young's double slit experiment is 6000 Å. The second and the fourth bright fringes from the centre of the fringe pattern are located respectively at 10.24 mm and 12.40 mm. If the observation screen is placed at a distance of 1 m from the slits, calculate the separation between the slits. (5)

   ii) A wedge shaped film is obtained by placing a thin wire between two plane glass plates at one end keeping them in contact with each other at the other end. When the film is illuminated by light of wavelength 6000 Å, 40 fringes are observed. Calculate the radius of the wire. (5)

   iii) Interference fringes are produced by a beam of monochromatic light incident normally on a wedge shaped film of refractive index 1.5. The angle of the wedge is 15 seconds of an arc and the two successive dark fringes are 0.4 cm apart. Calculate the wavelength of light. (5)

   iv) With the help of a diagram, explain the working of Michelson interferometer. Explain how Michelson interferometer can be used for determining the refractive index of a thin plate. (6+4)

3. i) Derive an expression for the intensity of the diffraction pattern obtained due to Fraunhofer diffraction from a single slit. (10)

   ii) A grating has 10,000 lines per cm. What is the maximum number of principal maxima that can be formed for light of wavelength 5×10^{-5} cm? (5)

   iii) 6 principal maxima are observed in the diffraction pattern due to a diffraction grating. Calculate the number of lines per cm in the grating if the wavelength of the light is 5000 Å. (5)

iv) A beam of parallel light of wavelength 6000 Å is incident normally on a 1 rupee coin of diameter 3 cm. If an observation screen is placed at a distance of 1 m from the coin, how many Fresnel zones would be obstructed by it (the coin)? For what separation between the coin and the screen, only 5 zones would be cut off? (5)

4. i) An atomic system consisting of two energy levels with population of higher energy level less than that of the lower level, is in thermal equilibrium. Show that the absorption of radiation dominates stimulated emission if radiation of appropriate frequency is introduced into the system. Comment on the consequences of this fact for laser action. (10)

ii) Why pumping is necessary for laser action? Compare and contrast three level and four level pumping schemes for lasers. (5)

iii) Two energy levels of an atomic system are separated by energy corresponding to frequency 5.0×10^{14} Hz. Assume that all atoms are in one or the other of these two energy levels. Compute the fraction of atoms in the upper energy level at temperature 600 K. Take $k_B = 1.38 \times 10^{-23}$ JK^{-1} and $h = 6.6 \times 10^{-34}$ Js. (5)

iv) The refractive indices of the core and cladding materials of an optical fibre are 1.64 and 1.53 respectively. Calculate the numerical aperture and light gathering capacity of the fibre. (5)

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