BPHET-141

ASSIGNMENT BOOKLET

BACHELOR'S DEGREE PROGRAMME
(BSCG)

ELEMENTS OF MODERN PHYSICS

Valid from 1st January, 2026 to 31st December, 2026

School of Sciences
Indira Gandhi National Open University,
Maidan Garhi, New Delhi-110068
(2026)

Dear Student,

Please read the section on assignments in the Programme Guide for B.Sc. that we sent you after your enrolment. A weightage of 30 per cent, as you are aware, has been earmarked for continuous evaluation, **which would consist of one tutor-marked assignment** for this course. The assignment is in this booklet, and it consists of two parts, Part A and B. The total marks of all the parts are 100, of which 35% are needed to pass it.

Instructions for Formatting Your Assignments

Before attempting the assignment please read the following instructions carefully:

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

ENROLMENT NO.: ……

NAME: ……

ADDRESS: ……

……

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COURSE CODE:……

COURSE TITLE: ……

ASSIGNMENT CODE: ……..

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.

5) Solve Part A and Part B of this assignment, and **submit the complete assignment answer sheets containing Parts A and B within the due date.**

6) The assignment answer sheets are to be submitted to your Study Centre as per the schedule. **Answer sheets received after the due date shall not be accepted.**

   We strongly suggest that you retain a copy of your answer sheets.

7) This assignment is **valid from 1st January, 2026 to 31st December, 2026**. If you have failed in this assignment or fail to submit it by December 31, 2026, then you need to get the assignment for the year 2027, and submit it as per the instructions given in the Programme Guide.

8) **You cannot fill the examination form for this course** until you have submitted this assignment. For any queries, please contact: slamba@ignou.ac.in, mbnewmai@ignou.ac.in

We wish you good luck.

Tutor Marked Assignment
ELEMENTS OF MODERN PHYSICS

Course Code: BPHET-141
Assignment Code: BPHET-141//TMA/2026
Max. Marks: 100

Note: Attempt all questions. The marks for each question are indicated against it.

PART A

1. a) A rod has a proper length of 2.0m. An observer measures its length as1.6 m. Calculate the speed of the rod. (5)

   b) A spaceship approachin Earth at a speed *c*/2, shoots a canister at a speed of 0.80c. Calculate the velocity of the canister for an observer on Earth if (i) the canister if it is shot directly toward Earth and (ii) if it is shot directly away from Earth. (5)

   c) A star emits light of wavelength 500 nm and recedes from Earth at speed 0.50c. Calculate the observed wavelength. (5)

   d) A particle moves with speed 0.8c. Calculate its momentum, kinetic energy and total energy. (5)

   e) An electric field of 10^6 Vm^{-1} is applied along the direction of motion of an electron moving with a speed of 0.6*c*. Calculate the acceleration of the electron. (5)

2. a) In a photoelectric effect experiment, it is seen that when light of wavelength 180 nm is incident on a metal, the measured photoelectric current drops to zero at a potential – 1.00 V. Calculate the work function of the metal and its cut-off frequency for photoelectric effect. (5)

   b) Electrons are accelerated through 150V and incident on a crystal with interatomic spacing *d* = 0.25 nm. Calculate the de Broglie wavelength and the first-order Bragg diffraction angle. (5)

   c) The average decay life time of an elementary particle is 1.0 μs. Calculate the minimum uncertainty in the measurement of its energy. Also, calculate the minimum uncertainty in the measurement of its mass using the mass-energy equivalence. (5)

   d) The normalized wave function for a particle is given by

$$\psi(x) = \begin{cases} 2a\sqrt{a}\, x\ e^{-ax}, & x > 0 \\ 0 \quad , & x < 0 \end{cases}$$

   Determine

   i) the value of *x* at which the probability density function is maximum, and

   iii) the probability of finding the particle between $x = 0$ and $x = 1/a$. (4+6)

PART B

3. a) The eigenfunction of a particle confined in a box of length L ($0 \le x \le L$) is

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

i) Show that $\psi_n(x)$ is not an eigenfunction of the momentum operator.

ii) Calculate the expectation value of the kinetic energy. (5+5)

b) Calculate the probability current density of the incident and reflected waves for the quantum mechanical particle incident on a step potential

$$V(x) = \begin{cases} 0 & , x < 0 \\ V_0 > 0 & , x > 0 \end{cases}$$

when $E < V_0$. (5)

c) Explain whether the eigen functions of the following Hamiltonian for a particle of mass m will have a definite parity: $H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2 x^2$. (5)

d) An electron with a energy of 8.0 eV strikes a potential barrier of energy 12.0 eV. If the tunnelling probability is 4.0 percent, determine the width of the barrier. (5)

4. a) The half-life of ^{14}C is known to be 5730 years. Calculate the decay constant (in s^{-1}). Also, calculate the rate of disintegration for 1 g of ^{14}C. (5)

b) Calculate the kinetic energy of the alpha particle emitted in the alpha decay of the Radium isotope $^{226}_{88}Ra$ $\left(^{226}_{88}Ra \rightarrow ^{222}_{86}Rn + ^{4}_{2}He\right)$. It is given that

$m\left(^{226}_{88}Ra\right) = 226.0254\,u$, $m\left(^{4}_{2}He\right) = 4.0026\,u$ and $m\left(^{222}_{86}Rn\right) = 222.0176\,u$. (5)

c) From the semi-empirical mass formula, calculate the value of the atomic number (Z) for the most stable nucleus at a given mass number A. Calculate Z_0 for A = 90. (5+5)

d) Two tritium $\left(^{3}_{1}H\right)$ nuclei fuse to release 11.3 MeV energy. Calculate the total energy released in the fusion of 1 kg tritium. (5)

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