BPHET-141

ASSIGNMENT BOOKLET

BACHELOR'S DEGREE PROGRAMME

(BSCG)

ELEMENTS OF MODERN PHYSICS

Valid from 1st January, 2023 to 31st December, 2023

School of Sciences
Indira Gandhi National Open University,
Maidan Garhi, New Delhi-110068
(2023)

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, 2023 to 31st December, 2023**. If you have failed in this assignment or fail to submit it by December 31, 2023, then you need to get the assignment for the year 2024, 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/2023
Max. Marks: 100

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

PART A

1. a) A muon produced in the earth's atmosphere is travelling with a speed of 0.80c. As measured in the muon's frame of reference it has a lifetime of 1.6 μs. What is it's lifetime as measured by an observer on earth. (5)

   b) A space ship is measured to be 180 m long on the ground. When in flight, its length is measured as 150 m by an observer on the ground. What is its speed? (5)

   c) Two β-particles move in opposite directions with velocities of 0.7*c* in the laboratory frame. Calculate the velocity of one β-particle in the moving frame attached to the other β-particle. (5)

   d) A light source emits light of wavelength 550 nm while at rest. When the source is moving, the Doppler shifted wavelength of the emitted light is 430 nm. Is the source of light approaching us or receding from us? Also calculate its speed. (5)

   e) Show that when the kinetic energy of a relativistic particle is equal to its rest energy, the speed of the particle is around 0.866c. (5)

2. a) The stopping potential observed in a certain experiment on photoelectric effect is 8.0 V. Calculate the maximum kinetic energy and maximum speed of the photoelectrons. (5)

   b) Calculate the de Broglie wavelength of an electron in the first Bohr orbit of the hydrogen atom. (5)

   c) Estimate the minimum kinetic energy a neutron confined to a nucleus of diameter 4×10^{-15} m may have. (5)

   d) Show that the wavefunction $\psi(x) = N \sin kx + iN \cos kx$ is an eigenfunction of the momentum operator. (5)

   e) In a region of space a particle has a wavefunction

$$\psi(x) = \begin{cases} A\cos\left(\dfrac{2\pi x}{L}\right) & \text{for } -\dfrac{L}{4} \le x \le \dfrac{L}{4} \\ 0 & \text{elsewhere} \end{cases}$$

   Determine the normalization constant *A.* (5)

PART B

3. a) A particle is in a one dimensional box of length *a*. If the particle is in the ground state, obtain Δx, where $(\Delta x)^2 = \langle x^2 \rangle - \langle x \rangle^2$. (10)

   b) A particle encounters a step potential of height V_0. Calculate the reflection and transmission coefficient if $E = 1.5V_0$? (5)

   c) Calculate the transmission coefficient for an electron of energy 2.0 eV incident on a potential barrier of 2.5 eV, if the width of the barrier is 0.50 nm. (5)

   d) For a symmetric potential function show that the parity operator commutes with the Hamiltonian. (5)

4. a) Determine B.E. per nucleon for $^{68}_{28}Ni$ given that the mass of *Ni* is 63.9280 u, m_p = 1.007825 u, m_n = 1.008665 u and m_e = .00054857u. (5)

   b) The half-life of an element C^{14} is 5370 yrs. Detrmine after how much time 40% of this sample would have decayed? (5)

   c) Show that for light nuclei, the fact that Z $\cong$ N is explained by the semi empirical formula. (5)

   d) Calculate the activity of 1g sample of Sr-90 whose half life is 28 years. Express your answer in units of Curie (*Ci*). Take $1\,Ci = 3.7 \times 10^{10}$ disintegrations s^{-1}. (5)

   e) Calculate Q value of the following nuclear reaction.

   $${}_{13}Al^{27} + {}_{2}He^{4} \longrightarrow {}_{14}Si^{30} + {}_{1}H^{1}$$

   Take $m\,({}_{13}Al^{27})$ = 26.9815 u, $m\,({}_{14}Si^{30})$ = 29.9738 u, $m\,({}_{2}He^{4})$ = 4.0026 u and $m\,({}_{1}H^{1})$ = 1.0078u. (5)

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