BPHET-141

ASSIGNMENT BOOKLET

BACHELOR'S DEGREE PROGRAMME
(BSCG)

ELEMENTS OF MODERN PHYSICS

Valid from 1st January, 2024 to 31st December, 2024

School of Sciences
Indira Gandhi National Open University,
Maidan Garhi, New Delhi-110068
(2024)

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, 2024 to 31st December, 2024**. If you have failed in this assignment or fail to submit it by December 31, 2024, then you need to get the assignment for the year 2025, 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/2024
Max. Marks: 100

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

PART A

1. a) Light takes 5.2 years to travel from a distant planet to earth. If the astronaut travelled from earth to that planet at a speed of 0.8 *c*, how long would it take according to the astronaut's clock, to reach the planet? (5)

   b) Calculate the linear momentum, total energy (in MeV) and kinetic energy (in MeV) of a particle travelling at 0.5 *c*, given that its rest mass is 938 MeV. (5)

   c) Two spaceships of proper length L_0 approach the earth from opposite direction at velocities $\pm 0.7c$. What is the length of one of the spaceships with respect to the other? (5)

   d) Calculate the relativistic mass and the rest mass of a negatively charged particle which has linear momentum of magnitude 1.80 x 10^{-21} kgms^{-1} at a speed of 0.9 *c*. (5)

   e) Derive the relativistic energy - momentum relation for a free particle. (5)

2. a) Light of frequency 6.0 x 10^{14} Hz is incident on a metal surface. Electrons with a maximum speed of 4.5 x 10^5 ms^{-1} are ejected from the surface. Calculate the work function and the cut-off frequency. (5)

   b) Determine the wavelengths of a photon and an electron having energy 5.0 x 10^3 eV and 5.5 x 10^3 eV respectively. Which of these would you use to probe atomic structures? (5)

   c) Use the uncertainty principle to estimate the approximate size of an atom. (5)

   d) The wave function of a particle of mass *m* that can move freely between $-L \le x \le L$ is given as:

$$\psi(x,t) = \begin{cases} A\cos\left(\frac{2\pi x}{L}\right)\exp\left(-\frac{iEt}{\hbar}\right) & \text{for } -L < x < L \\ 0 & \text{elsewhere} \end{cases}$$

   Using time dependent Schrodinger equation, determine the value of the constant *E*. (5)

   e) Show that $\left[\hat{L}_y, \hat{L}_x\right] = -i\hbar\hat{L}_z$. (5)

PART B

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

$$\psi(x) = A\sin\left(\frac{4\pi x}{L}\right)$$

Determine the normalization constant A, the expectation value of the kinetic energy and the probability of finding the particle between $x = L/2$ and $x = 3L/4$.

(5+5+5)

b) A particle of energy 4 eV is incident of a potential with energy 8 eV. Calculate the distance in which the probability of finding the particle becomes 0.04 as it goes into the "forbidden" region. (5)

c) Calculate the penetration depth for an electron of energy 30 eV, trapped by an electrostatic potential 80 eV. How much energy would be required to "free" the electron from the well? (5)

4. a) Plot a graph of the binding energy per nucleon as a function of mass number. Write the main features of the curve. (3+2)

b) The mean life of an element is 18 months. Determine the time required for 60% of the element to decay. (5)

c) Calculate the kinetic energy of an alpha particle emitted in the alpha decay of uranium isotope ${}^{233}_{92}U \rightarrow {}^{229}_{90}Th + \alpha$ particle . It is given that $m\left({}^{233}_{92}U\right) = 233.0396343\,\text{u}$, $m\left({}^{229}_{90}Th\right) = 229.03176\,\text{u}$ and $m\left({}^{4}_{2}H\right) = 4.002603\,\text{u}$. (5)

d) Calculate the energy of reaction (Q-Value) in MeV in the fusion reaction of Deuterium-Tritium into helium:

$${}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + n$$

Take $m\left({}^{2}_{1}H\right) = 2.0141029\,\text{u}$, $m\left({}^{3}_{1}H\right) = 3.016049\,\text{u}$, $m\left({}^{4}_{2}He\right) = 4.0026\ \text{u}$ and $m(n) = 1.008665\,\text{u}$. (5)

e) The half-life of ^{232}Th is known to be 14×10^{9} yrs. Calculate the decay constant (in s^{-1}) and the rate of disintegration for 1 g of Thorium. (5)

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