BPHET-141

ASSIGNMENT BOOKLET

BACHELOR'S DEGREE PROGRAMME

(BSCG)

ELEMENTS OF MODERN PHYSICS

Valid from 1st January, 2022 to 31st December, 2022

School of Sciences
Indira Gandhi National Open University
Maidan Garhi, New Delhi-110068
(2022)

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:

ROLL 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 Jan., 2022 to 31st Dec., 2022**. If you have failed in this assignment or fail to submit it by **31st Dec., 2022**, then you need to get the assignment for the year 2023, 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/2022

Max. Marks: 100

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

PART A

1. a) Two observers observe two events from different inertial frames of reference in uniform relative motion at a speed of 0.90c. Under what condition would the observers observe these events to be simultaneous? Write down all possible conditions under which the events would not be simultaneous for the two observers. (5)

   b) The mean lifetime of a particle is 2.5 μs when it is produced in the top layers of the Earth's atmosphere. If it travels at the speed of 0.9999c, what is its life time as measured by an observer on the Earth? Calculate the distances travelled by the particle in its own frame of reference and the Earth's frame of reference. (2+1+2)

   c) The speed of a particle relative to an observer on the Earth is 0.80c, and the speed of another particle relative to her is – 0.90c. What is the speed of the particles with respect to each other? (5)

   d) A particle of rest mass 1.0 kg has an initial speed of $1.0\times10^{8}\,\text{m s}^{-1}$. A constant relativistic force of magnitude $5.0\times10^{6}\,\text{N}$ is exerted on the particle in the same direction as the initial relativistic momentum for 100 s. Calculate the magnitudes of the initial and final relativistic linear momenta of the particle. (5)

   e) Calculate the linear momentum, kinetic energy and total energy (in J and MeV) of a particle travelling with speed 0.90c given that its rest mass is $1.68\times10^{-27}\,\text{kg}$ and $1\,\text{MeV} = 1.6\times10^{-13}\,\text{J}$. (5)

2. a) Calculate the cut-off wavelength for aluminium, which has a work function of 4.08 eV. Will photoelectrons be emitted when radiation of wavelength 400 nm is incident on an aluminium surface? (5)

   b) Calculate the de Broglie wavelength of a non-relativistic proton with a kinetic energy of 10 eV. (5)

   c) An excited state in an atom has a life time of $3.0\times10^{-7}\,\text{s}$. Calculate the line width of the emitted photon, when the atom decays spontaneously to its ground state. (5)

   d) The wave function of a particle is given by:

$$\psi(x) = \begin{cases} N\cos\dfrac{ax}{2}, & -\dfrac{\pi}{a} \le x \le \dfrac{\pi}{a} \\ 0\ , & \text{elsewhere} \end{cases}$$

Calculate

(i) the normalisation constant N, and

(ii) probability of finding the particle in the region $0 \le x \le \frac{\pi}{2a}$ (5+5)

PART B

3. a) Write down the wave function for the first excited state of a particle in a one dimensional box of length L. Calculate $< x >$ and $< p_x >$ for this state. (2+3+5)

b) What is quantum tunneling? Calculate (i) the tunneling length and (ii) the tunneling probability when an electron of energy 4.0 eV is incident on a potential barrier of height 10 eV and width of 0.2 nm. (2+3+5)

c) Explain whether the eigen functions of the following Hamiltonian for a particle of mass m will have a definite parity:

$$H = \frac{p^2}{2m} + \frac{1}{2}\alpha x^4$$ (5)

4. a) Draw a curve of binding energy per nucleon as a function of mass number and explain the main characteristics of elements and also the phenomena of nuclear fission and fusion. (5)

b) The half-life of an element I^{131} is 8.05 days. After how many days will only 10% of this element be left over? (5)

c) Do electrons reside inside the nucleus? Explain. (5)

d) A sample of pitchblende contains 50 kg uranium. The half-life of uranium is 4.5×10^9 yr. The atomic weight of uranium is 238.4. The total number of uranium atoms in the beginning is 1.269×10^{26} atoms. Calculate the age of the sample. (5)

e) Draw the schematic diagram of a nuclear fission reactor. Write its general features. Discuss the role of a fast breeder reactor. (5)

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