PHE-11

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

MODERN PHYSICS

Valid from January 1, 2024 to December 31, 2024

It is compulsory to submit the Assignment before filling up the Term-End Examination Form.

Please Note

- **You can take electives (56 or 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 out of those 64 credits should be from lab courses.**
- **You cannot appear in the Term-End Examination of any course without registering for the course. Otherwise, your result will not be declared and the responsibility will be yours.**

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THE PEOPLE'S UNIVERSITY

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

2024

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 would consist of **one tutor-marked** assignment for this course.

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 : ………………………………………

………………………………………

………………………………………

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.
5) While solving problems, clearly indicate the question number along with the part being solved. Be precise. 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, 2024 to December 31, 2024**. However, you are advised to submit it within **12 weeks** of receiving this booklet to accomplish its purpose as a teaching-tool.

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
MODERN PHYSICS

Course Code: PHE-11
Assignment Code: PHE-11/TMA/2024
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. a) The earth and the sun are 8.3 light-minutes apart in the same inertial frame. Two events occur at $t = 0$ on the earth and $t = 3$ minutes on the sun respectively. Calculate the time difference between the events according to an observer moving at $u = 0.6c$ from the earth to the sun. (1 light minute is the distance travelled by light in one minute.) (5)

   b) Supersonic jets are able to achieve maximum speeds of up to $3.0 \times 10^{-6}c$. Calculate the percentage contraction in the length of a jet plane travelling at this speed. (5)

   c) The rest energy of a proton is 938 MeV. If its kinetic energy is also 938MeV, calculate its momentum and speed. (5)

   d) Missiles are fired towards the earth from a spacecraft. The missiles are moving with a speed of $0.8c$ with respect to the spacecraft. If the spacecraft itself has a speed of $0.3c$ with respect to Earth, how fast are the missiles observed to travel with respect to Earth? (5)

   e) A star emits light with wavelength 120 nm. An observer on earth measures the wavelength of the light received from the star to be 600 nm. Calculate the speed with which the star is moving. (5)

2. a) Using Heisenberg's uncertainty principle, estimate the energy and radius of the ground state of a hydrogen-like atom made of a proton and a muon. Assume that the proton and the muon are bound by the Coulomb potential $V(r) = \dfrac{e^2}{4\pi\varepsilon_0 r}$. The mass of the muon is 106 MeV/c^2. (5)

   b) Calculate the deBroglie wavelength of a ^{87}Rb atom that has been laser cooled to 120 μK. (Assume that the kinetic energy is $\dfrac{3}{2}k_B T$). (5)

   c) A particle of mass m and zero energy has a wave function $\psi(x) = N\,x\,e^{-\frac{x^2}{16}}$, where N is a constant. Determine the potential energy $V(x)$ for the particle. (5)

   d) Calculate the commutator $\left[p, \mathrm{e}^{ik_0 x}\right]$ where the function $\mathrm{e}^{ik_0 x}$ may be expanded as:

$$\mathrm{e}^{ik_0 x} = \sum_{n=0}^{\infty} \frac{(ik_0 x)^n}{n!}.$$ (5)

e) The wave function of a particle moving in the x-direction is given by:

$$\psi(x) = \begin{cases} Nx(l-x), & 0 < x < L \\ 0 \quad , & \text{elsewhere} \end{cases}$$

Calculate the normalization constant. (5)

3. a) Calculate the mean kinetic energy and potential energy of the 1-dimensional oscillator in the ground state having angular velocity ω. (10)

b) State Moseley's law. Using this law, obtain the frequency of an X-ray line when L to K transition takes place in a silver atom. Take $\sigma = 3$. (5)

c) Obtain the ground state terms of Li and Si. (5)

d) Obtain the average value of r of a hydrogen atom in its ground state. (5)

4. a) A radioisotope P has a half-life of 3 s. At $t = 0$, a given sample of this isotope contains 8000 atoms. Calculate (i) its decay constant, (ii) average life, (iii) the time t_1 when 1000 atoms of the isotope P remain in the sample, and (iv) number of decays per second in the sample at $t = t_1$ s. (5)

b) Establish the relation for binding energy per nucleon for ${}^{A}_{Z}X$ nuclei. Calculate the value of binding energy per nucleon for ${}^{68}_{28}\text{Ni}$. Given:

Mass of Ni	:	63.9280 u
Mass of proton	:	1.007825 u
Mass of neutron	:	1.008665 u

Is this nucleus stable? (10)

c) Identify whether the following particles are leptons, baryons or mesons:

μ, Λ, η°, π°, p, π^+, ν_e, τ, Σ^+, n (5)

d) Discuss in brief the following:

i) Synchrotrons ii) Counters (5)

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