PHE-11

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

MODERN PHYSICS

Valid from January 1, 2021 to December 31, 2021

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

2021

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 : ………………………………………

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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, 2021 to December 31, 2021**. 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/2021
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) A muon produced in the Earth's atmosphere is travelling with a speed of $0.90c$. As measured in the muon's frame of reference, it has a lifetime of 1.6 μs. What is its lifetime as measured by an observer on Earth? (5)

   b) A space ship is measured to be 140 m long on the Earth. When in flight, its length is measured as 120 m by an observer on the Earth. What is its speed? (5)

   c) A man on the Moon observes two spaceships moving towards him from opposite directions at speeds of $0.7c$ and $0.8c$, respectively. What is the relative speed of the two space ships as measured by an observer on either one? (5)

   d) A light source emits light of wavelength 125 nm while at rest. When the source is moving, the Doppler shifted wavelength of the emitted light is 375 nm. Is the source of light approaching us or receding from us? Also calculate its speed. (5)

   e) The kinetic energy of an electron is equal to its rest mass energy. Determine the magnitude of its velocity and momentum. (5)

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

   b) The kinetic energy of an electron is 13.6 eV. Calculate its de Broglie wavelength. (5)

   c) Show that the wavefunction $\psi(x) = N\sin kx + iN\cos kx$ is an eigen function of the momentum operator and determine its eigen value. (5)

   d) Determine the normalization constant A for the wave function:

   $$\psi(x) = A\sin\left(\frac{2\pi x}{L}\right) \quad \text{for} \quad -\frac{L}{4} \le x \le \frac{L}{4}, \qquad (5)$$

   e) 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)

3. a) The wave function of a particle in an infinite square well of width $2a$ ($-a$ to a) is given by,

   $$\psi(x) = \left(\frac{1}{a}\right)^{1/2}\cos\left(\frac{3\pi x}{2a}\right).$$

   Determine $< x^2 >$ for the particle. (5)

b) For a simple harmonic oscillator, show that the expectation value of x, defined as

$< x >_{mn} = \int \psi_m^* (x)\ \psi_n (x)\ dx$ is $\sqrt{\dfrac{1}{2a^2}}$ for the $n = 0$ and $m = 1$ states. Use the

result $\int_0^\infty x^{\frac{1}{2}} e^{-x}\, dx = \sqrt{\pi}$. (10)

c) i) Write down the electronic configuration of Ca^{20} and Sr^{38} and their ground state spectral terms. (5)

ii) At what potential difference must an X-ray tube operate to produce X-rays with a minimum wavelength of 2 Å ? (5)

4. a) How are radioisotopes produced? Describe three examples of their use as tracers. (5)

b) A reactor is producing energy at the rate of 32×10^6 watts. How many atoms of U^{235} undergo fission per second? Assume that on the average, energy of 200 MeV is released per fission. (5)

c) i) Explain with reason whether the following reactions are possible or not: (2)

i) $\pi^+ + p \rightarrow \wedge + K^\circ$

ii) $\pi^- + p \rightarrow n + \pi^\circ$

ii) Classify the following particles as anti-leptons, baryons and mesons:

$\sum^\circ, \Omega^-, \mu^+, e^+, \pi^\circ, \eta^\circ$ (½×6=3)

d) The mean life of a radioactive element is 17.31 months. Calculate the time required for 75% of the element to decay. (5)

e) Define the binding energy of nuclei. Draw a graph between binding energy per nucleon as a function of mass number. Write the main features of the curve. (5)

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