PHE-11

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

MODERN PHYSICS

Valid from January 1, 2022 to December 31, 2022

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.**

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

2022

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, 2022 to December 31, 2022**. 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/2022
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 rod of length 2.0 m at rest in the S' frame is tilted at an angle of 60° with respect to the x' axis. If the speed of S' with respect to the S frame is 0.5c, calculate the length of the rod in the S frame and the angle it makes with the x-axis. (10)

   b) A spaceship approaching the Earth at a speed of 0.6c, shoots a bullet towards the earth at a speed of 0.7c. What will be the speed of the bullet as measured by an observer on earth. (5)

   c) The maximum wavelength of light emitted in the Balmer series of Hydrogen is 656 nm. This wavelength when emitted by a distant star is measured to be 1500 nm. Calculate the speed of the star. (5)

   d) The total energy of an electron produced in a nuclear reaction is 1.5 MeV. Calculate the momentum of the electron and its speed in the laboratory frame. The rest mass of the electron is 9.1×10^{-31} kg and its rest energy is 0.51 MeV. (5)

2. a) The lifetime of the excited state of an atom is 2.0×10^{-31} s. Calculate the minimum uncertainty in its energy and the line width of the spectral line. (5)

   b) Determine the potential difference through which an electron at rest must be accelerated in an electron microscope such that its de Broglie wavelength is 0.05 nm. (5)

   c) The wave function for a particle of mass m is:

   $$\psi(x) = A\sin\left(\frac{4\pi x}{L}\right) \text{ for } 0 \le x \le L$$

   Calculate

   i) the normalization constant A, and
   ii) the expectation value of the momentum $< p_x >$ (5+5)

   d) Determine the value of the commutator $\left[L_z, L^2\right]$ (5)

3. a) Obtain the average value of r and potential energy $V(r) = -\frac{e^2}{r}$ of a hydrogen atom in its ground state:

   $$\psi_{100}(r) = \frac{1}{\sqrt{\pi}\, a_0^3} e^{-r/a_0}.$$ (10)

b) i) Obtain the ground state terms of *Li* and *Si*.

ii) State with reasons whether following transitions for a multielectron atom are allowed:

$$^3P_0 \rightarrow {}^3S_1;\ {}^3S_1 \rightarrow {}^1S_0;\ {}^1S_{1/2} \rightarrow {}^1D_{3/2}$$ (5)

c) What are characteristic x-rays? Write the selection rules for x-ray spectra. Draw approximate energy levels for *L* and *M* shells and show all the allowed transitions. (5)

d) The wave function of a particle of mass *m* inside an infinite square well of width $2a\,(-a \text{ to } +a)$ is given by

$$\psi(x) = A\cos\frac{3\pi x}{2a} + B\sin\frac{3\pi x}{2a}$$

Obtain the values of *A* and *B* and the eigenenergy corresponding to the above eigenfunction. (5)

4. a) The half-life of ^{235}U is 7.0×10^8 years. Calculate the disintegration constant per second. Also, calculate the number of distintegrations per second from 1g of uranium. Take Avogadro's number $= 6.03\times10^{23}$. (5)

b) Plot a graph of the number of neutrons versus the number of protons for naturally occurring nuclei. Write the main features of the curve. (5)

c) Determine the mass defect of ^4He and hence calculate its binding energy. Compare it with the value obtained on the basis of semi-empirical mass formula.

Given

$$m_n = 1.008665\,\text{u};\quad M(\text{He}) = 4.002604\,\text{u};\quad m_p = 1.007825\,\text{u}$$ (5)

d) Discuss the general features of a nuclear reactor. What is the difference between shim control rods and regulating rods? (5)

e) Write a short note on the followings:

i) Synchrotrons

ii) Scintillation counter (5)

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