BPHE-104/PHE-04

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

MATHEMATICAL METHODS IN PHYSICS-I

Valid from January 1, 2023 to December 31, 2023

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

2023

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, 2023 to December 31, 2023**. 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
MATHEMATICAL METHODS IN PHYSICS-I

Course Code: BPHE-104/PHE-04
Assignment Code: BPHE-104/PHE-04/TMA/2023
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) Find two unit vectors perpendicular to both $\vec{\mathbf{A}} = 2\hat{\mathbf{i}} - \hat{\mathbf{j}} + 3\hat{\mathbf{k}}$ and $\vec{\mathbf{B}} = -2\hat{\mathbf{i}} + 4\hat{\mathbf{j}} + \hat{\mathbf{k}}$. (5)

   b) For the vectors $\vec{\mathbf{a}}$, $\vec{\mathbf{b}}$, $\vec{\mathbf{c}}$ and $\vec{\mathbf{d}}$ show that:

$$(\vec{\mathbf{a}} \times \vec{\mathbf{b}}) \cdot (\vec{\mathbf{c}} \times \vec{\mathbf{d}}) + (\vec{\mathbf{b}} \times \vec{\mathbf{c}}) \cdot (\vec{\mathbf{a}} \times \vec{\mathbf{d}}) + (\vec{\mathbf{c}} \times \vec{\mathbf{a}}) \cdot (\vec{\mathbf{b}} \times \vec{\mathbf{d}}) = 0 \qquad (5)$$

2. a) Show that

$$\vec{\nabla} \cdot (r^n \,\hat{\mathrm{r}}) = (n+2)\, r^{n-1}$$

   where $\hat{\mathbf{r}}$ is the unit vector along $\vec{\mathbf{r}}$. (5)

   b) For what value of a is the following vector field irrotational:

$$\vec{\mathbf{A}} = (axy - z^3)\,\hat{\mathbf{i}} + (a-2)\,x^2\hat{\mathbf{j}} + (1-a)\,xz^2\hat{\mathbf{k}} \qquad (5)$$

3. a) For the vectors

$$\vec{\mathbf{A}} = t^2\,\hat{\mathbf{i}} - t\,\hat{\mathbf{j}} + 2t\,\hat{\mathbf{k}} \quad \text{and} \quad \vec{\mathbf{B}} = (t-1)\hat{\mathbf{i}} + \hat{\mathbf{j}} + t\,\hat{\mathbf{k}}$$

   Find $\dfrac{d}{dt}\left(\vec{\mathbf{A}} \times \dfrac{d\vec{\mathbf{B}}}{dt}\right)$ (5)

   b) Evaluate $\vec{\nabla} \cdot (\vec{\mathbf{A}} \times \vec{\mathbf{r}})$ if $(\vec{\nabla} \times \vec{\mathrm{A}})$ is zero. (5)

4. a) Obtain the gradient of the following scalar field:

$$U(\rho, \phi, z) = \rho^2 z \cos 2\phi \qquad (5)$$

   b) Express the following vector field in spherical polar coordinates:

$$\vec{\mathbf{A}} = x\,\hat{\mathbf{i}} + 2y\hat{\mathbf{j}} + yz\hat{\mathbf{k}} \qquad (5)$$

5. a) Calculate the directional derivative of the scalar field $f(x, y, z) = x^2 z + y^3 z^2 - xyz$ in the direction $\hat{\mathbf{i}} + 2\hat{\mathbf{k}}$ at the point(1, 1,1). (5)

   b) A plane sheet of material is bound by the curve $y = x^2$ from $x = 0$ to $x = 1$, the x-axis and the line $x = 1$. If the mass per unit area (density) of the sheet is xy find the mass of the sheet. (5)

6. Determine the work done in moving a particle in the force field
$\vec{\mathbf{F}} = 3x^2\hat{\mathbf{i}} + (2xz - y)\hat{\mathbf{j}} + z\hat{\mathbf{k}}$ along the curve

$$x = 2t^2, \quad y = t, \quad z = 4t^2 - t$$

from $t = 0$ to $t = 1$. (10)

7. Evaluate $\iint \vec{\mathbf{A}} \, . \hat{\mathbf{n}} \, dS$, where $\vec{\mathbf{A}} = 2x \cos^2 y \, \hat{\mathbf{i}} + 3xz \, \hat{\mathbf{j}} + 2z \sin^2 y \, \hat{\mathbf{k}}$, over the surface of a sphere with its centre at the origin and radius of 8 units. (10)

8. Use Stokes's Theorem to evaluate the integral:

$$\oint_C (x + 2z)dx + (x - y)dy + 2xdz$$

where C is an ellipse defined by the following:

$$\frac{x^2}{9} + \frac{y^2}{16} = 1; z = 1$$ (10)

9. a) In bulbs manufactured in a factory, it is seen that 5% of the bulbs are found to be defective. What is the probability that in a batch of 10 bulbs no more than two are defective? (5)

   b) Power cuts in a locality occur according to a Poisson distribution with an average of 3 power cuts every 15 weeks. Calculate the probability that in a particular week there will not be more than one power cut. (5)

10. The number of revolutions per minute (x) and power (y) hp of a diesel engine are tabulated below.

x	400	500	600	700	750
y	600	1000	1450	1900	2100

Obtain the regression equation for this data. (10)

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