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

MATHEMATICAL METHODS IN PHYSICS-I

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.**

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THE PEOPLE'S
UNIVERSITY

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:

$$\text{ENROLMENT NO.} \quad : \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots$$

$$\text{NAME} \quad : \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots$$

$$\text{ADDRESS} \quad : \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots$$

$$\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots$$

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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
MATHEMATICAL METHODS IN PHYSICS-I

Note: Attempt all questions. Symbols have their usual meanings. The marks for each question are indicated against it.

1. a) Determine the volume of a tetrahedron whose vertices are given by the points (0,0,0), (2,2,0), (-3,2,1) and (4,3,2). (5)

   b) For a vector $\vec{\mathbf{a}}$ show that:

   $$\hat{\mathbf{i}} \times (\vec{\mathbf{a}} \times \hat{\mathbf{i}}) + \hat{\mathbf{j}} \times (\vec{\mathbf{a}} \times \hat{\mathbf{j}}) + \hat{\mathbf{k}} \times (\vec{\mathbf{a}} \times \hat{\mathbf{k}}) = 2\vec{\mathbf{a}}$$ (5)

2. a) Obtain the unit tangent vector for a vector function
   $$\vec{\mathbf{a}}(t) = (2t^2 + t)\hat{\mathbf{i}} + (3t^3 - 4)\hat{\mathbf{j}} + (6t + 1)\hat{\mathbf{k}} \text{ at } t = 2.$$ (5)

   b) Determine the direction in which the scalar field $f(x, y, z) = xy^3 - z - 2$ decreases most rapidly at the point $O(1,2,3)$ and the magnitude of this rate of change. (5)

3. a) Show that the following vector field $\vec{\mathbf{F}}$ is irrotational:

   $$\vec{\mathbf{F}} = (2z^4 - 2y + y^3)\hat{\mathbf{i}} + (z - 2x + 3xy^2)\hat{\mathbf{j}} + (6 + y + 8xz^3)\hat{\mathbf{k}}.$$ (5)

   b) For $\vec{\mathbf{r}} = x\hat{\mathbf{i}} + y\hat{\mathbf{j}} + z\hat{\mathbf{k}}$, show that:

   $$\vec{\nabla}.(r^{-4}\vec{\mathbf{r}}) = -r^{-4}$$ (5)

4. a) Write the function $\phi(x, y, z) = \ln\left(\sqrt{x^2 + y^2 + 3z^2}\right)$ in cylindrical coordinates and determine the gradient of the function. (5)

   b) Obtain the divergence of the following vector field:

   $$\vec{\mathbf{A}} = \left(\frac{3}{r^2}\sin\theta\,\hat{\mathbf{e}}_r + 2r\cot\theta\,\hat{\mathbf{e}}_\theta + r\sin\theta\cos\phi\,\hat{\mathbf{e}}_\phi\right)$$ (5)

5. Determine the work done by a force $\vec{\mathbf{F}} = x^2\,\hat{\mathbf{i}} + x^2\hat{\mathbf{j}} + yz\,\hat{\mathbf{k}}$ in taking a particle along the path defined by the equation $\vec{\mathbf{r}}(t) = \cos t\,\hat{\mathbf{i}} + \sin t\,\hat{\mathbf{j}} + t\hat{\mathbf{k}},\ 0 \le t \le \pi$ from $t = 0$ to $t = \pi$. (10)

6. Using Stokes' Theorem evaluate the line integral $\int_C \vec{\mathbf{F}}.d\vec{\mathbf{l}}$ where

   $\vec{\mathbf{F}} = 2x^2 z\hat{\mathbf{i}} + 5x\hat{\mathbf{j}} - 3y^3\hat{\mathbf{k}}$ and C is the circle $x^2 + y^2 = 4$ oriented counterclockwise. (10)

7. Using Green's Theorem evaluate the integral: $\int_C 3x^3 y\,dx + (y^2 - 4)dy$ where C is the

   rectangle with vertices at (0,0), (5,0), (5,2) and (0,2). (10)

8.   Determine the mass of a box which occupies the volume defined by the equations $0 \le x \le 1; 0 \le y \le 2; 0 \le z \le 3$ has a density $\rho(x, y, x) = 5x^2 yz$ units .   (10)

9. a) Suppose that 10% of the adults who take a certain medicine suffer negative side effects. Using a binomial distribution calculate the probability that in a random sample of 10, more than three will experience negative side effects.   (5)

    b) Suppose a given website receives an average of 4 visitors per hour. Using a Poisson distribution calculate the probability that the website receives less than 7 visitors in a given hour.   (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	580	1030	1420	1880	2100

Obtain the regression equation for this data.   (10)

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