BPHE-104/PHE-04

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

MATHEMATICAL METHODS IN PHYSICS-I

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.**

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 : ………………………………………

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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, 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
MATHEMATICAL METHODS IN PHYSICS-I

Course Code: BPHE-104/PHE-04
Assignment Code: BPHE-104/PHE-04/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) Calculate the volume of the tetrahedron whose vertices are the points A = (3, 2, 1), B = (1, 2, 4), C = (4, 0, 3) and D = (1, 1, 7). (5)

   b) For three vectors $\vec{\mathbf{u}}$, $\vec{\mathbf{v}}$ and $\vec{\mathbf{w}}$ show that:

$$(\vec{\mathbf{u}} \times \vec{\mathbf{v}}).[(\vec{\mathbf{v}} \times \vec{\mathbf{w}}) \times (\vec{\mathbf{w}} \times \vec{\mathbf{u}})] = [\vec{\mathbf{u}}.(\vec{\mathbf{v}} \times \vec{\mathbf{w}})]^2 \ .$$ (5)

2. a) Obtain the derivative and the unit tangent vector for a vector function

$$\vec{\mathbf{a}}(t) = t\,\hat{\mathbf{i}} + e^{t^2}\hat{\mathbf{j}} + \sin 2t\,\hat{\mathbf{k}}$$ (5)

   b) For a scalar field $\phi(x, y, z) = x^n + y^n + z^n$, where n is a non-zero real constant, show that $(\vec{\nabla}\phi).\vec{\mathbf{r}} = n\phi.$ (5)

3. a) Determine the value of the constant a for which the vector field $\vec{\mathbf{F}} = (2x^2 y + z^2)\,\hat{\mathbf{i}} + (xy^2 - x^2 z)\,\hat{\mathbf{j}} + (axyz - 2x^2 y^2)\,\hat{\mathbf{k}}$ is incompressible. (5)

   b) Show that for any vector field $\vec{\mathbf{F}}$

$$\vec{\nabla}.(\vec{\nabla} \times \vec{\mathbf{F}}) = 0.$$ (5)

4. a) Obtain the divergence of the following vector field:

$$\vec{\mathbf{A}} = \left(\rho^3 \hat{\mathbf{e}}_\rho + \rho z \hat{\mathbf{e}}_\phi + \rho z \sin\phi\, \hat{\mathbf{e}}_z\right)$$ (5)

   b) Determine the metric coefficients for the coordinate system (u,v,z) whose coordinates are related to the Cartesian coordinates by the following equations:

$$x = \frac{1}{2}\left(u^2 + v^2\right); \ y = 2uv; \quad z = z$$

   Is the system orthogonal? (5)

5. The position vector of an object of mass m moving along a curve is given by $\vec{\mathbf{r}}(t) = at^2\,\hat{\mathbf{i}} + \sin bt\,\hat{\mathbf{j}} + \cos bt\,\hat{\mathbf{k}}, \ 0 \le t \le 1$, where a and b are constants. Calculate the force acting on the object and the work done by the force. (10)

6. Using Stokes' theorem evaluate $\int_C \vec{\mathbf{F}}\,.d\vec{\mathbf{l}}$ where $\vec{\mathbf{F}} = y\hat{\mathbf{i}} + xz^3\,\hat{\mathbf{j}} - z\,y^3\hat{\mathbf{k}}$ and C is the circle $x^2 + y^2 = 4; z = -3.$ (10)

7. a) Show that $\vec{\nabla}\left(\frac{r}{1+r^2}\right)=\frac{1-r^2}{\left(1+r^2\right)^2}\hat{\mathbf{e}}_r$. (5)

b) Using Green's Theorem evaluate the integral $\oint_C (xydx+x^2y^3dy)$ where C is the triangle with vertices (0,0), (1,0) and (1,2). (5)

8. a) An unbiased coin is tossed three times. If A is the event that a head appears on each of the first two tosses, B is the event that a tail occurs on the third toss and C is the event that exactly two tails appear in the three tosses, show that:

i) Events A and B are independent
ii) Events B and C are dependent. (5)

b) A random variable X has the following probability distribution:

$$f(x)=\begin{cases}\dfrac{4}{\pi(1+x^2)} & \text{for} \quad 0<x<1\\ 0 & \text{elsewhere}\end{cases}$$

Calculate $E(X)$. (5)

9. a) Out of 90 applicants for a job, 60 people get selected after the interview. If five applicants are selected at random, calculate the probability that 2 will get selected. (5)

b) A metal sheet has, on the average, 5 defects per 10 sq. ft. Assuming a Poisson distribution, calculate the probability that a 15 sq. ft. piece of the metal sheet will have at least 4 defects. (5)

10. The measurements of the bulk modulus of a material at different temperatures is as follows:

T(°C)	20	500	1000	1200	1400	1500
K (G Pa)	203	197	191	188	186	184

Determine the regression equation for this data. (10)

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