BPHE-104/PHE-04

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

MATHEMATICAL METHODS IN PHYSICS-I

Valid from January 1, 2025 to December 31, 2025

It is compulsory to submit the Assignment before filling in 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
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2025

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 : ……

……

……

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, 2025 to December 31, 2025**. 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/2025
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) Obtain a unit vector perpendicular to the plane of the vectors $\vec{\mathbf{A}} = 3\hat{\mathbf{i}} - 4\hat{\mathbf{j}} + 2\hat{\mathbf{k}}$ and $\vec{\mathbf{B}} = \hat{\mathbf{i}} + \hat{\mathbf{j}} + 3\hat{\mathbf{k}}$. (5)

   b) For any four vectors $\vec{\mathbf{a}}, \vec{\mathbf{b}}, \vec{\mathbf{c}}$ and $\vec{\mathbf{d}}$ determine:

   $$(\vec{\mathbf{a}} \times \vec{\mathbf{b}}).(\vec{\mathbf{c}} \times \vec{\mathbf{d}}) + (\vec{\mathbf{b}} \times \vec{\mathbf{c}}).(\vec{\mathbf{a}} \times \vec{\mathbf{d}}) + (\vec{\mathbf{c}} \times \vec{\mathbf{a}}).(\vec{\mathbf{b}} \times \vec{\mathbf{d}}).$$ (5)

2. a) Obtain a unit tangent vector to any point on the curve defined by the parameteric equations:

   $$x = \sin 3t; y = 2\cos 3t; z = 4t.$$ (5)

   b) Obtain the directional derivative for a scalar field $\phi(x, y, z) = 3x^2y - y^3z^2$ at the point (1, –2, –1) in the direction $\hat{\mathbf{i}} + \hat{\mathbf{j}} + \hat{\mathbf{k}}$. (5)

3. a) Evaluate $\vec{\nabla}.(r^3\vec{\mathbf{r}})$. (5)

   b) Show that for any scalar field ϕ:

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

4. Obtain the divergence and curl of the following vector field:

   $$\vec{\mathbf{A}} = \left(\rho^3\hat{\mathbf{e}}_\rho + \rho z\hat{\mathbf{e}}_\phi + \rho z\sin\phi\hat{\mathbf{e}}_z\right)$$ (10)

5. Calculate the work done by a force $\vec{\mathbf{F}} = (x - y)\hat{\mathbf{i}} + xy\,\hat{\mathbf{j}}$ in moving a particle counter-clockwise along the circle $x^2 + y^2 = 4$ from the point (2, 0) to the point (0, –2). (10)

6. Using the divergence theorem evaluate $\iint_S \vec{\mathbf{F}} . d\vec{\mathbf{S}}$ where $\vec{\mathbf{F}} = y^2z\hat{\mathbf{i}} + y^3\,\hat{\mathbf{j}} + xz\,\hat{\mathbf{k}}$ and S is the surface of the cube defined by $-1 \le x \le 1; -1 \le y \le 1; 0 \le z \le 2.$ (10)

7. a) Calculate the divergence of the vector function $\vec{\mathbf{F}} = r^2\sin\theta\hat{\mathbf{e}}_r$ (5)

   b) Using Green's Theorem evaluate the integral $\oint_C (y^3dx - x^3dy)$ where C is a circle of radius 3 units centered at the origin. (5)

8. a) The construction of a building may be delayed by a strike. Suppose that the probability that there will be a strike is 0.70, the probability that the construction

will be completed on time if there is no strike is 0.90 and the probability that the building will be completed on time if there is a strike is 0.40, what is the probability that the construction will be completed on time. (5)

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

$$f(x) = \begin{cases} kx(1-x) \text{ for } \quad 0 < x < 1 \\ \\ 0 \qquad \text{elsewhere} \end{cases}$$

Determine the value of the constant k and $E(X)$. (5)

9. a) An athlete is running in four races and in each race she has a 60% chance of winning. What is the probability that she will win at least two races? (5)

b) A website has on the average two hits per hour. Assuming a Poisson distribution for the number of hits per hour (X), calculate the probability that there are at most three hits. (5)

10. The modulus of rigidity of a wire is

$$\eta = \frac{2LN}{\pi r^4 \theta}$$

The following measurements are made for L, r and θ / N

$r = 1.5 \pm 0.05$ mm

$L = 400 \pm 2$ mm

$\frac{\theta}{N} = 6.00 \pm 0.20$ rad N^{-1} m^{-1}

Obtain the best value of η. (10)

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