



RAN-1803080101010001

M.Sc. (Sem.-I) Examination November - 2025

Physics : Mathematical Methods of Physics (Paper : PH-411)

Time: 3 Hours]
[Total Marks: 70
સૂચના : / Instructions

- (1) ઉપરોક્ત દર્શાવેલ વિગતો ઉત્તરવહી પર અવશ્ય લખવી.
Fill up strictly the above details on your answer book
- (2) Symbols used have their usual meaning.
- (3) Figures to the right indicate full marks

Seat No.:

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Student's Signature

Q.1. Answer ANY TWO of the following.

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|-----|------|--|---|
| (A) | (i) | What are ordinary points, singular points, and regular singular points in differential equations? | 3 |
| | (ii) | Solve $(1 - x^2)y'' - 2xy' + p(p + 1)y = 0$ about $x = 0$ using Taylor power series. | 6 |
| (B) | (i) | Determine the order and degree of $\frac{dy}{dx} = e^{x+y} + x^2e^y$ and solve using variable separable method. | 3 |
| | (ii) | Define general and particular solutions for Clairaut's equation and solve
$y = x \left(\frac{dy}{dx} \right) + \left(\frac{dy}{dx} \right)^2$ | 6 |
| (C) | (i) | Solve the given homogeneous ordinary differential equation
$x^2y'' + 2xy' - 6y = 0$. | 3 |
| | (ii) | Solve $y'' + y = \sec x$ using the method of variation of parameter. | 6 |

Q.2. Answer ANY TWO of the following.

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|-----|------|--|---|
| (A) | (i) | Find the Laplace transform of $f(t) = \cosh \omega t$. | 3 |
| | (ii) | Obtain Laplace transform of function $f(t) = e^{at} \sin \omega t$. | 6 |
| (B) | (i) | Explain the three types of singularities (removable, pole, and essential) in complex functions. | 3 |
| | (ii) | State Cauchy's Residue Theorem. Using the theorem, evaluate
$\oint \frac{1-2z}{z(z-1)(z-2)} dz$, where $ z = 1.5$. | 6 |
| (C) | | Define Fourier transform. Prove that the Gaussian function remains Gaussian under Fourier transform for $f(r) = \left(\frac{2}{\pi a^2} \right)^{3/4} e^{-r^2/a^2}$. | 9 |

Q.3. Answer ANY TWO of the following.

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|-----|------|---|---|
| (A) | (i) | Provide definitions and brief descriptions of Legendre, Associated Legendre, Bessel, Spherical Harmonics, and Hankel functions. | 9 |
| | (ii) | Obtain the generating function $F(h, x)$ for Legendre polynomials. | 5 |
| (B) | (i) | Derive Schlafli's integral representation for Legendre polynomials. | 4 |

- (C) Obtain the values of Legendre polynomials $P_n(x)$ for $n = 0$ to 5 using Rodrigues' formula. 9

Q.4. Answer ANY TWO of the following.

- (A) (i) State and describe the three basic axioms of probability. 4
(ii) Define group with closure, associativity, identity, and inverse properties. 4
Explain group order.
- (B) (i) Explain the concepts of permutations and combinations and provide one example. 4
(ii) Discuss the key properties of skewness and kurtosis in a probability distribution. 4
- (C) Explain in detail the three fundamental probability distributions: Binomial, Poisson, and Gaussian. 8
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