Seat No. : _____

NG-149

November-2025

M.Sc., Sem.-III

PHY-502 : Physics

(Numerical Analysis and Classical Mechanics – II)

(New Course)

Time : 2:30 Hours] **[Max. Marks : 70**

1. (A) Explain Picard's methods for solving first order ordinary differential equation. Discuss its advantages and disadvantages. **7**

1. (B) Using Milne's method of solving ODE, obtain a solution y(0.8) of the equation, $\frac{dy}{dx} = x - y^2$. **7**

The data given are :

X	0	0.2	0.4	0.6
Y	0.0000	0.0200	0.0795	0.1762

OR

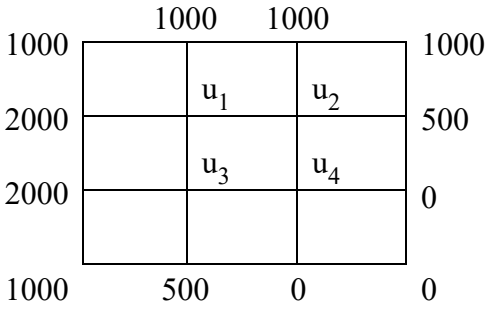
1. (A) Explain Runge-Kutta methods of first order to fourth order for solving first order ordinary differential equation. **7**

1. (B) Using Adams-Beshforth method of solving ODE, obtain a solution y(1.2) of the equation

$\frac{dy}{dx} = \frac{y - x}{y + x}$; y(0) = 1. Choose h = 0.2 **7**

2. (A) Explain how second order partial differential equation is classified ? Discuss in detail Finite difference approximations to partial derivatives. **7**

2. (B) Given the values of u(x, y) on the boundary of the square in the following figure. Evaluate the function u(x, y) satisfying the Laplace equation $\nabla^2 u = 0$ at the pivotal points of this figure by Jacobi's method. **7**



OR

2. (A) Explain Schmidt method and Crank-Nicolson method for solving one dimensional heat equation. **7**

2. (B) Evaluate the pivotal values of the equation $u_{tt} = 16u_{xx}$, taking $\Delta x = 1$ up to t = 1.25. The boundary conditions are u(0, t) = u(5, t) = 0, $u_t(x, 0) = 0$ and $u(x, 0) = x^2(5 - x)$. **7**

3. (A) Obtain an expression for the phase trajectory of a Simple pendulum. Hence discuss the three cases of phase trajectories for (a) $E_1 < 2$ mgl, (b) $E_1 = 2$ mgl, (c) $E_1 > 2$ mgl. **7**

3. (B) Obtain an expression for the time period of simple pendulum in terms of its amplitude (θ_0), i.e., obtain $T = \frac{4}{\omega_0} K(k)$, where $k = \sin\left(\frac{\theta_0}{2}\right)$. **7**

OR

3. (A) Discuss the Non-linear non-conservative system and obtain the expression for the phase trajectory. Discuss Limit cycle for its phase trajectory. **7**

3. (B) Discuss the Logistic map. Also discuss the Logistic map for $\mu = 2.9$. **7**

4. (A) Discuss the relativistic dynamics and obtain the expressions for the force $\overline{F}_{\perp} = F/\gamma$ and $\overline{F}_{||} = F_{||}$. Hence obtain an expression for the Minkowski force. **7**

4. (B) Obtain an expression for the Compton wavelength of an electron in terms of scattering angle. **7**

OR

4. (A) Discuss the motion of a particle under a constant force and show that the graph of position against time is a parabola classically, but it is hyperbola when we consider relativistic motion of the particle. **7**

4. (B) Write transformation equations for the components of electric field and magnetic field. Hence show that $\overline{E} \cdot \overline{B}$ and $\overline{E}^2 - c^2\overline{B}^2$ are relativistically invariant. **7**

5. Attempt any **seven** questions from the following. Each question carries **two** marks. **14**

(1) A solution which cannot be obtained from a general solution is called _____ solution.

(A) Particular (B) Singular

(C) Undetermined (D) Zero

(2) **Assertion (A) :** Multi-steps methods are self-starting methods.

Reason (R) : Multi-steps methods not require some of the previous approximate values to compute the successive point.

(A) Both Assertion (A) and Reason (R) are true.

(B) Both Assertion (A) and Reason (R) are false.

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false, but Reason (R) is true.

(3) **Assertion (A) :** The Picard's Method and Taylor's series method of solving differential equation numerically have some restrictions.

Reason (R) : In these methods, labour involved in finding the higher order derivatives and successive integrations, respectively.

(A) Both Assertion (A) and Reason (R) are false.

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(4) The region in which the given equation acts as a parabolic partial differential equation is _____.

$x^3 u_{xx} + 27u_{yy} + 3u_{xy} + 56x = 0$

(A) $x = \left(\frac{1}{12}\right)^{\frac{1}{3}}$ (B) $x < \left(\frac{1}{12}\right)^{\frac{1}{3}}$

(C) $x > \left(\frac{1}{12}\right)^{\frac{1}{3}}$ (D) For any real value of x

(5) Which relation is true for u_{xy} ?

(A) $u_{xy} = \left[\frac{u_{i+1, j+1} - u_{i+1, j-1} + u_{i-1, j-1} - u_{i-1, j+1}}{4} \right]$

(B) $u_{xy} = \left[\frac{u_{i+1, j+1} - u_{i+1, j-1} + u_{i-1, j-1} - u_{i-1, j+1}}{h^2} \right]$

(C) $u_{xy} = \left[\frac{u_{i+1, j+1} + u_{i+1, j-1} + u_{i-1, j-1} + u_{i-1, j+1}}{4\ hk} \right]$

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(6) The classification of following second order PDE is :

$$(1 + x) \frac{\partial^2 u}{\partial x^2} + 2xy \frac{\partial^2 u}{\partial x \partial y} - y^2 \frac{\partial^2 u}{\partial y^2} = 0$$

(A) Parabolic : on x-axis.
Hyperbolic : If $y \neq 0$, $y^2 > 0$ and when $(x^2 + x + 1) > 0$
Elliptical : If $y \neq 0$, $y^2 > 0$ and when $(x^2 + x + 1) < 0$

(B) Parabolic : on y-axis.
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(D) Parabolic : on x-axis.
Hyperbolic : on y-axis
Elliptical : in xy-plane

(7) For the stability of a fixed point attractor, $\left| f'\mu(x^*) \right|$ should be _____.

(8) What do you mean by bifurcation ?

(9) What do you mean by chaotic motion ?

(10) When an object of mass m is at rest, its relativistic energy is _____.

(11) Write the transformation equations for the proper velocity 4-vector.

(12) Write an expression for the relativistic mass relating the rest mass.

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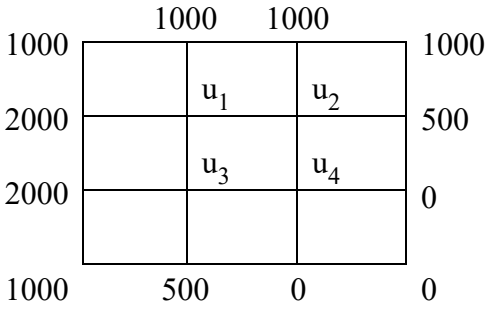

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3. (A) Draw the circuit diagrams of even and odd parity generation using IC-74180 and explain its working. **7**

3. (B) Draw the circuit diagram of Switched tail Counter and its truth table to explain its working. **7**

OR

3. (A) Drawing the circuit diagram of Monostable Multivibrator using IC-555, explain the working of the circuit. **7**

3. (B) Explain the working of IC-7490 as Mod 10 counter in (5 × 2) configuration, drawing necessary circuit diagram, truth table and waveforms. **7**

4. (A) Explain the working of resistive divider network drawing necessary circuit diagram. Discuss the drawbacks of the circuit. **7**

4. (B) Discuss the working of A/D converter using counter method, drawing necessary block diagram. **7**

OR

4. (A) Explain the D/A conversion Accuracy and Resolution. **7**

4. (B) Discuss the working of A/D converter using Successive Approximation, drawing necessary block diagram. **7**

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(7) In PROM design each x represents _____ and each solid black bullet represents _____.

(8) The x's on the input side PAL are _____, while the solid black bullets on the output side are _____.

(9) A TTL clock circuit provides a 6-MHz clock frequency with a stability better than 10 parts per million (ppm) over a 24-h time period. What are the frequency limits of the clock ?

(10) Find the output pulse width for the monostable timer using IC-555. Given RA = 10 k ohm and C = 0.5 μF.

(11) Find the output voltage from a 6-bit ladder that has a digital input of 010110. Assume that 0 = 0 V and 1 = +10 V.

(12) What is the value of V_A for a 5-bit resistive divider if the digital input is 01111 ? Assume 0 = 0 V and 1 = +10 V.