



2023

1st Semester Examination (CCFUP : NEP)

PHYSICS

Paper : MI 1-T (Minor)

(Mathematical Physics and Mechanics)

Full Marks : 40

Time : Two Hours

*The figures in the margin indicate full marks.
Candidates are required to give their answers
in their own words as far as practicable.*

Group - A

Answer any **five** of the following questions : $2 \times 5 = 10$

1. Determine whether the differential $Mdx + Ndy$ is exact or inexact, where $M = 2xy + 3$ and $N = x^2 - y$. 2
2. Solve the second-order linear differential equation with constant coefficients : $y'' - 3y' + 2y = 0$. 2
3. Write Green's theorem and Stoke's theorem. 2
4. What is Stoke's law in a high viscous liquid? 2
5. Define the directional derivative. 2
6. Write the relation between surface tension and the total surface energy per unit area. 2

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7. Find a unit normal to the surface $xy^2 + 3xyz = 5$ at the point $(0, 1, 0)$. 2
8. Draw gravitational potential Energy and field intensity of a solid sphere with the distance from its centre point. 2

Group - B

Answer any *four* of the following questions :

5×4=20

9. A satellite of mass $m = 1000$ kg is in a circular orbit around Earth at an altitude of 200 km above the Earth's surface. Given, the mass of Earth $M_e = 5.97 \times 10^{24}$ kg and the gravitational constant $G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2$, calculate the velocity of the satellite in its orbit. Also, find the period of the satellite's orbit. 5
10. Derive Poiseuille's equation for flow of a liquid through a capillary tube. 5
11. Find the angle in between face diagonals of a cube with unit length using vector method. 5
12. Prove $\nabla(r^2) = 2\vec{r}$; symbols have their usual meaning. 5
13. What is an inertial frame of reference? What are non-inertial frames? Is any natural frame inertial? 2+2+1

14. A cylindrical body of radius $R = 0.3\text{m}$, mass $M = 2\text{ kg}$, and moment of inertia $I = 0.03\text{ kg.m}^2$ about its symmetry axis is rolling without slipping down an inclined plane with an angle of inclination $\theta = 30^\circ$. Calculate the acceleration of the body's centre of mass as it rolls down the plane. Assume there is no air resistance. 5

Group - C

Answer any *one* of the following questions :

10×1=10

15. Deduce the expression for the capillary rise of a liquid and hence deduce Jurin's law. Derive the expression for the pressure difference at inside and outside of a soap bubble. 5+2+3
16. (a) Derive the relation between Young's modulus, shear modulus and poisson's ratio; similarly find the relation between Young's modulus, bulk modulus and poisson's ratio.
- (b) A solid cylindrical steel wire of diameter 0.5 cm and length 2 m is fixed at one end and twisted by applying a torque of 10 N.m at the other end. If the shear modulus (modulus of rigidity) of steel is $8 \times 10^{10}\text{ N/m}^2$, calculate the angle of twist in degrees and the maximum shear stress in the wire. 6+4