

Tribhuvan University

2081

Bachelor Level (4 Yrs.)/Science & Tech. / III year

Math Physics & Classical Mechanics

PHY 301 (New Course)

Full Marks: 100

Time: 3 hrs.

*Candidates are required to give their answers in their own words as far as practicable.*

*The figures in the margin indicate full marks.*

Attempt ALL the questions.

1. State and explain Bessel differential equation if the function  $f_n(x)$  obeys the recurrence relations.  $f_{n-1}(x) + f_{n+1}(x) = \frac{2n}{x} f_n(x)$   
and  $f_{n-1}(x) - f_{n+1}(x) = 2f_n'(x)$   
then prove that  $f_n(x)$  satisfies the Bessel differential equation. [10]

OR

Distinguish between Laplace and Poisson's equation. Deduce the Laplace equation in spherical polar coordinates.

2. Derive a relation between momentum and energy for a relativistic particle and interpret it. [8]

OR

Discuss Hamilton's principle to non-holonomic systems. How the method of Lagrange undetermined multiplier is useful while dealing with non-holonomic systems? Explain.

3. State D' Alembert's principle. Use this principle to derive Lagrange's equation of motion. [8]
4. Define symmetric and skew-symmetric tensors. Show that every tensor can be expressed as the sum of two tensors in which one is symmetric and another is skew-symmetric in a pair of covariant and contravariant indices. [10]
5. Describe the theory and hence the motion of a symmetrical top. [8]

6. Given function  $f(x) = x^2$ . Sketch the function in the range  $(-\pi \leq x \leq \pi)$  and expand  $f(x)$  in a Fourier series for  $(-\pi \leq x \leq \pi)$ . [10]
7. Answer all questions [2×3=6]  
 (a) State Kepler's laws of motion.  
 OR  
 Explain the meaning of linear operators.
- (b) Elucidate the concepts of scalar and vector fields with examples.  
 OR  
 Clarify the significance of Foucault's pendulum.
8. Answer all questions [5×3=15]  
 (a) Interpret the meaning of Christoffel's symbols with examples.  
 (b) What is meant by Hermitian matrix? Give an example.  
 (c) Describe Dirac-delta function.  
 (d) Differentiate between rotational and irrotational vectors.  
 (d) Explain Rutherford scattering (No derivation is required).
9. Find the number of degrees of freedom for a rigid body which (a) can move freely in space, (b) has two fixed points. [5]
10. A particle leaving a cyclotron has a total relativistic energy of 10 GeV and a relativistic momentum of 8 GeV/c. Calculate the rest mass of the particle. [5]
11. Given  $\vec{v} = (x + 3y)\vec{i} + (y - 2z)\vec{j} + (x + az)\vec{k}$  such that  $\nabla \cdot \vec{v} = 0$ . Determine the value of 'a' which is constant. [5]
12. Find the inverse of matrix  $A = \begin{pmatrix} 1 & 3 \\ 2 & 1 \end{pmatrix}$ . [5]
13. Calculate the Laplace Transform of  $f(x) = e^x$ . [5]

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