Mid-West University

Examinations Management Office

End Semester Examination 2081

Bachelor level/ B. Sc./ 7th Semester — Full Marks: 100

Time: 3 hours — Pass Marks: 50

Subject: Classical Mechanics and Relativity (PHY471)

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

Group - A

1. Answer in short any <u>EIGHT</u> questions. [8x2 = 16]

a. Write the difference, for example, between a rheonomic and scleronomic constraints.

b. What is the cyclic coordinate? How the symmetry corresponds to conservation laws?

c. Obtain the angular momentum of a rigid body by rotating on its axis with constant angular velocity.

d. What is the precession for rotating symmetrical top?

e. Explain the meaning of normal coordinates and normal frequencies.

f. What is a light cone?

g. What is meant by time dilation?

h. What is meant by Legendre transformation? Write the transformation equation.

i. Show that the acceleration is invariant under Galilean transformation.

j. What is small oscillation? Find its potential energy.

Group - B

2. Answer in brief any <u>SIX</u> questions. [6x6 = 36]

a. What do you understand by generalized force and momentum? Show that the generalized momentum corresponding to a cyclic coordinate is a constant of motion.

b. Define variational principle? Explain the significance of Hamiltonian principle.

c. What do you mean canonical transformation? Prove that the Poisson bracket under canonical transformation is invariant, $[\boldsymbol{X}, \boldsymbol{Y}]_{\boldsymbol{q},\boldsymbol{p}} = [\boldsymbol{X}, \boldsymbol{Y}]_{\boldsymbol{Q},\boldsymbol{P}}$.

d. State Euler's theorem and derive Euler's equation of motion.

e. What is the meaning of mass-energy equivalence? Obtain Einstein's mass-energy relation.

f. Discuss the vibration of linear diatomic molecules.

g. What are the characteristics of a rigid body? Obtain an expression for the rotational K.E. of the rigid body.

Group - C

3. Define Euler's angles and obtain an expression for the complete transformation matrix. Derive the equation of motion of a symmetrical top under the action of gravity. Discuss its precession, and spin dynamics. **[3+6]**

4. Write down basic postulates of Einstein's special theory of relativity. Hence develop the Lorentz space-time transformation equations. Also, explain the law of addition of velocities. **[2+7]**

OR

Obtain Lagrange's equations of motion using the D'Alembert principle for a holonomic system. Derive the equation of motion for a simple pendulum by using Lagrange's equation of motion. **[4+5]**

5. Using the Poisson bracket, show that the transformation defined by $q = \sqrt{2P}\sin Q$, $p = \sqrt{2P}\cos Q$ is canonical. **[6]**
6. Find the kinetic energy of rotation of a rigid body concerning the principal axis in terms of Eulerian angles and interpret the result when $I_1 = I_3$. **[6]**
7. Obtain the equation of motion for a simple pendulum $\ddot{\theta} + \frac{g}{l}\theta = 0$, using the Hamiltonian equation of motion. Given Lagrangian $L = \frac{1}{2}ml^2\dot{\theta}^2 - mg$. **[6]**

OR

A particle of rest mass m_0 moves with speed, $\frac{c}{\sqrt{3}}$. Calculate its mass, momentum, total energy, and kinetic energy. **[6]**

8. Rocket A travels to the right and Rocket B travels to the left, with velocities $0.8c$ and $0.6c$, respectively, relative to the earth. What is the velocity of rocket A measured from rocket B? **[6]**
9. Find the equation of motion of one-dimensional harmonic oscillator using Hamilton's principle. **[6]**

The End