Mid-semester Examination 2024-25

PH100: Mechanics and Thermodynamics

Time: 120 Minutes Marks: 30

- **All questions are compulsory and their marks are indicated in square brackets.**
- **All questions need to be answered sequentially without fail. Non-compliance with instructions will invite a deduction in marks.**
- **In case you feel any question/s is/are incorrect or have insufficient instruction then write in the answer book with your justification without wasting any time.**

---

1. Answer the following questions briefly.

   (a) State and explain Newton's laws of motion.

   (b) Write down the velocity and acceleration in the plane polar coordinates. Find the rate of change of radial and tangential vector with respect to time.

   (c) If the work integral $\int_a^b \boldsymbol{F}.\boldsymbol{dl}$ is path-independent, then $\boldsymbol{F}$ must be a non-conservative force. (True/False) Under what conditions, $\boldsymbol{F}$ can be a conservative force?

   (d) What is the quality factor of an oscillator? Estimate its magnitude for a lightly damped oscillator.

   (e) Let consider two masses m_1 and m_2 under the influence of central force. Discuss the scenario in which these two masses remain bounded. [10 Marks]

2. (a) State Kepler's laws of planetary motion. (b) Before landing men on the moon, the Apollo 11 space vehicle was put into orbit about the moon. The mass of the vehicle was *9,979* kg and the period of the orbit was *119* minutes. The maximum and minimum distances from the center of the moon were 1,861 km and *1,838* km. Assuming the moon to be a uniform spherical body, what is the mass of the moon according to these data? G=6.67 * 10^{-11} N.m^2/kg^2. [3+4=7 Marks]

3. With physical examples, discuss undamped, damped, forced, and forced damped harmonic oscillation. Consider the forced harmonic oscillation and forced damped harmonic oscillation with the driving force as $F_0 cos(\omega_d t)$ and the damping force as $-bv$. By plotting the displacement curve, discuss the resonance situation in both cases. [6 Marks]

4. (a) What do you understand from elastic and inelastic collisions? Give physical examples.

   (b) A particle of mass m and velocity v_0 collides elastically with a particle of mass M initially at rest and is scattered through angle θ in the center of the mass system. (i) Find the final velocity of m in the laboratory system. (ii) Find the fractional loss of kinetic energy of m. [3+4=7 Marks]
