Cluster Innovation Centre, University of Delhi, Delhi-110007

Examination	**: End Semester Examination – March 2022**
Name of the Course	**: B.Tech (Information Technology and Mathematical Innovations)**
Name of the Paper	**: Physics at work I – Deconstructing Machines**
Paper Code	**: 32861105**
Semester	**: I**
Duration	**: 3 Hours**
Maximum Marks	**: 75**

Instructions: This question paper contains six questions, out of which any four are to be attempted. Each question carries equal marks.

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1. Derive the expression for the terminal velocity of a metallic sphere of radius r and mass density ρ dropped into a fluid of density σ and coefficient of viscosity η. How can we measure η experimentally? State and explain the Ladenberg correction. Show that a falling raindrop moves at the terminal velocity for $t \gg \tau$, where τ is the characteristic time of the motion.

2. Prove that there are four points of oscillation about which the time period of a compound pendulum is the same. How do we use this information to construct a bar pendulum and use it to measure g? What is the experimental advantage of a Kater's pendulum over a Bar pendulum in measuring the value of g?

3. From Newton's second law, derive the expression for the centre of mass of a system of discrete particles. Extend the formula to an extended body of continuous mass. Use the expression to derive the centre of mass of a triangular plate of mass M, base b, height h, and small thickness t.

4. Describe the construction of an inverted pendulum. If the inverted pendulum is released from rest at an angle θ_0, what will be its velocity at angle θ_f? How does the motion of a double pendulum differ from an inverted pendulum? With neat drawings/sketches, explain how you can construct a double pendulum for a student demonstration.

5. A commonly used potential energy function to describe the interaction between two atoms is the Lennard-Jones 6-12 potential given by

$$U = \epsilon\left[\left(\frac{r_0}{r}\right)^{12} - 2\left(\frac{r_0}{r}\right)^{6}\right]$$

   Find the position of the potential minimum and its value. Near the minimum, the atoms execute simple harmonic motion. Find the frequency of oscillation.

6. Write and solve the equation of motion for the damped harmonic oscillator. Show that the energy dissipates exponentially. Derive the expression for the Q – factor. Draw the graph of the motion. How can we measure experimentally the frequency of oscillation of a damped harmonic oscillator?