1. (20 points) Three particles A, B, and C with masses \( m_A = 2m_B = m_C \) are arranged (in that order) in a straight line. Initially, B and C are at rest a distance \( L \) apart, and A is projected towards B with speed \( v_A \). The particles then undergo elastic head-on collisions.
   a) (5 points) Show that for any elastic head-on collision, the relative speed of the two objects after the collision has the same magnitude (but opposite direction) as before the collision
   \[
   v_A - v_B = -(v'_A - v'_B),
   \]
   Where primes define quantities after the collision.
   (This equation is simpler to use than the conservation of energy.
   b) (15 points) Show that A and B collide twice and that the time interval between these two collisions is \( \Delta t = \frac{12L}{7v_A} \).

2. (10 points) A thin uniform rod of length \( l \) and mass \( m \) has its two ends constrained to move on the circumference of a smooth vertical circle of radius \( R \). The circle doesn’t move.
   a) Introduce a parameter to describe the system.
   b) Write down the total PE of the system as a function of the parameter.
   c) Determine conditions for equilibrium and classify it as stable or unstable.

3. (10 points) Prove that the force \( F = (yz, zx, xy) \) acting on a particle is conservative and find the potential energy \( U(x,y,z) \).

4. (10 points) Two masses are connected by a cord passing over a pulley of radius \( R \) and moment of inertia \( I \). Mass \( m_1 \) slides on a frictionless surface, and \( m_2 \) hangs freely. Determine
   a) a formula for the angular momentum of the system about the pulley axis, as a function of the speed \( v \) of mass \( m_1 \) or \( m_2 \);
   b) if angular momentum is conserved;
   c) The acceleration of the masses.