1. (10%) Describe and illustrate the role and use of particle model in classical dynamics.

2. (15%) Formulate the dynamic equation for Newtonian particles system and extend your result to rigid body dynamics.

3. (15%) Prove that for a particle moving in a central force field ($\mathbf{F} = F(r)$, r = radial distance), the angular momentum is conserved and the motion is planar.

4. (10%) Each of two balls has mass m, as shown in Fig. 1. If A is released from rest at θ, determine the angle ϕ to which B rises after collision. The coefficient of restitution between the two balls is e. (Ignore friction force.)

5. (30%) As shown in Fig. 2, one end of bar BC is connected to bar AB by a hinge. The other end of bar BC moves along the horizontal smooth guide. If a couple moment (T) of 150 N-m is applied on bar BC with the system initially at rest in the given configuration, determine the resulting angular acceleration of bar AB and the reaction forces at A and C. The mass (m) of bar BC is 30 kg. Neglect the mass of bar AB. The radius of gyration (k) of bar BC about its mass center is 0.5 m.

6. (20%) As shown in Fig. 3, a circular disk rolls without sliding on a circular surface. The radius (R) of the circular surface is 1 m, and the radius (r) of the disk is 0.2 m. The center of the disk is hinged to one end of a slender bar AB, and the other end of bar AB is hinged to the center of the circular surface. The mass (M) of bar AB is 40 kg, and the mass (m) of the disk is 20 kg. A constant force (F) of 100 N is applied on the mass center of bar AB as the disk moves from $\theta = 0$ (at rest) to $\theta = 30°$, and the line of action of F is always vertical. Determine the angular velocity of the disk at $\theta = 30°$.

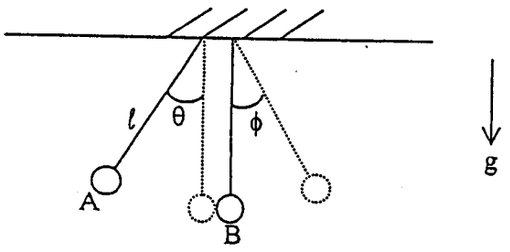

Fig. 1

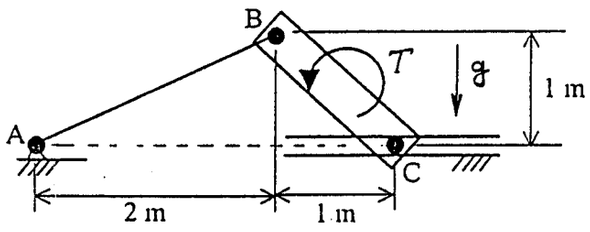

Fig. 2

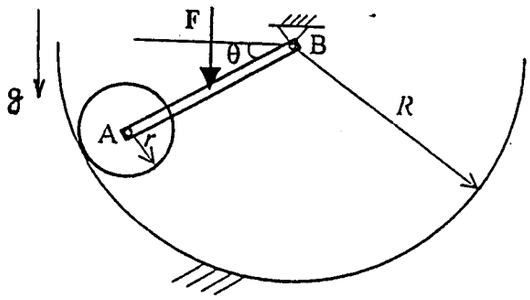

Fig. 3