1. (10%) Consider Figure 1 as shown below. The 1-kg slider A fits loosely in the smooth 45° slot in the disk, which rotates in a horizontal plane about its center O. If A is held in position by a cord secured to point B, determine the tension T in the cord for a constant rotational velocity $\omega = 180$ rev/min.

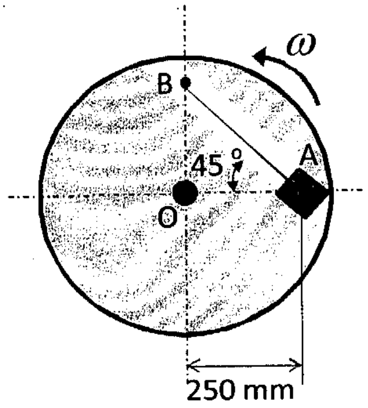

Fig. 1

2. (20%) Consider the Figure 2 below. A simple pendulum of mass m and length r is mounted on the flatcar which has a constant horizontal acceleration a_0 as shown. If the pendulum is released from rest relative to the flatcar at the position $\theta = 0$, determine the expression of the tension T in the supporting light rod for any value of θ. Also find T for $\theta = \pi/2$.

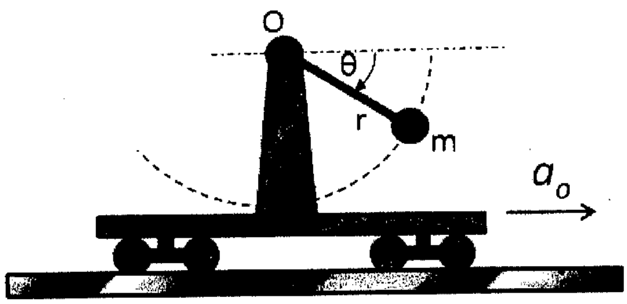

Fig. 2

3. (15%) The gear train shown in Figure 3 consists of a *sun*, a *planet* and an *arm*, where the gear ratio of the sun to the planet is ρ. As the sun is kept still and the arm is rotated clockwise with an angular speed ω, what is the angular velocity of the planet?

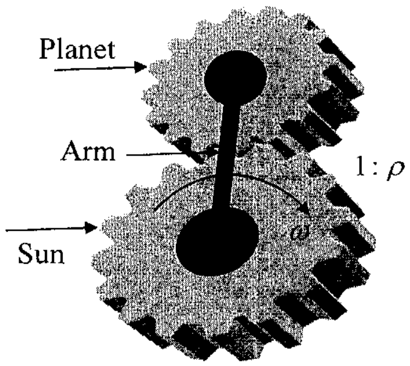

Figure 3. Planetary gears

4. (25%) A circular loop with uniform density is rolling down along an inclined plane angling $\theta = 30^\circ$ from the horizon, as shown in Figure 4.
   (a) (15%) When there is no slipping between the circular loop and the plane, what is the acceleration of the mass center of the loop?
   (b) (10%) What is the minimized coefficient of friction on the plane to guarantee that the loop rolls without slipping eventually?

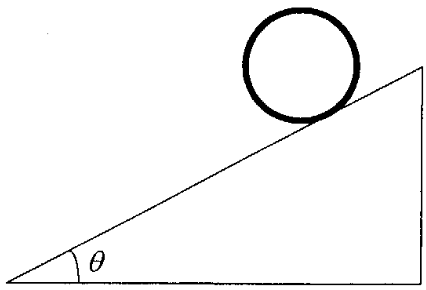

Figure 4. Pure rolling

5. (20%) As shown in Figure 5, the uniform rod $\mathcal{R}$ with length equal to 80 cm and mass 20 kg is smoothly pinned to cart $\mathcal{C}$ at point A. Force P, applied to $\mathcal{C}$ with the system initially at rest, causes $\mathcal{C}$ to translate with the initial acceleration equal to 3 m/s^2←. The center of mass of the rod $\mathcal{R}$ is located at point B. The initial angular acceleration of the rod is given as α.
   (a) (10%) Please express the initial acceleration of the point B (a_B) as a function of α.
   (b) (10%) Please determine the value of α.

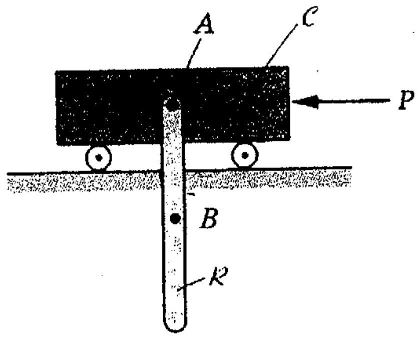

Figure 5

6. (10%) The mass-damper-spring system is shown in Figure 6. The displacement of the mass m is given as x(t) and the excitation displacement is given as y(t). Please derive the differential equation of motion for the system.

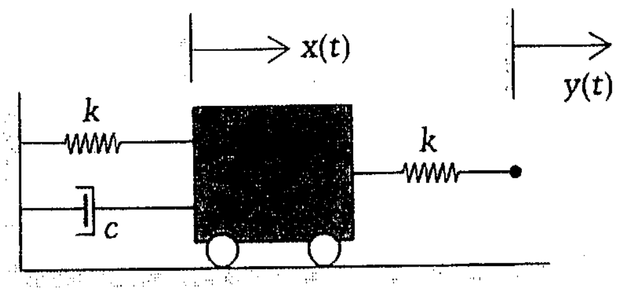

Figure 6