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](image)

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 \( \theta \). Also find \( T \) for \( \theta = \pi/2 \).

![Fig. 2](image)
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 $\rho$. As the sun is kept still and the arm is rotated clockwise with an angular speed $\omega$, what is the angular velocity of the planet?

![Figure 3. Planetary gears](image)

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](image)
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 $3 \text{ m/s}^2$. The center of mass of the rod $\mathcal{R}$ is located at point $B$. The initial angular acceleration of the rod is given as $\alpha$.

(a) (10%) Please express the initial acceleration of the point $B$ ($a_B$) as a function of $\alpha$.

(b) (10%) Please determine the value of $\alpha$.

![Figure 5](image1.png)

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](image2.png)