**SEOUL NATIONAL UNIVERSITY**
**SCHOOL OF MECHANICAL AND AEROSPACE ENGINEERING**

**SYSTEM ANALYSIS** **Spring 2015**

**HW#3** **Assigned : March 19 (Th)**
**Due: March 31 (Tu)**

1. **A radar tracks the flight of a projectile (see Figure 1). At time t, the radar measures the horizontal component $v_x(t)$ and the vertical component $v_y(t)$ of the projectile's velocity and its range $R(t)$ and elevation $\pi(t)$. Are these measurements sufficient to compute the horizontal distance $D$ from the radar to the launch point of the projectile? If so, derive the expression for $D$ as a function of g and the measured values $v_x(t)$, $v_y(t)$, $R(t)$, and $\pi(t)$.**

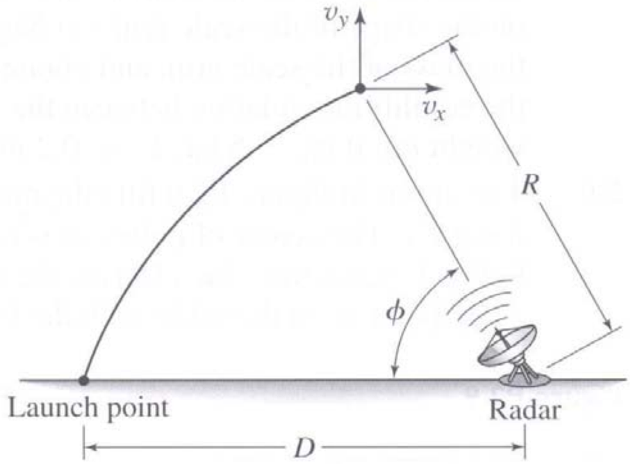


**Figure 1**

2. **The motor in Figure 2 lifts the mass $m_L$ by winding up the cable with a force $F_A$. The center of pulley $B$ is fixed. The pulley inertias are $I_B$ and $I_C$. Pulley $C$ has mass $m_c$. Derive the equation of motion in terms of the speed $v_A$ of point $A$ on the cable with the force $F_A$ as input.**

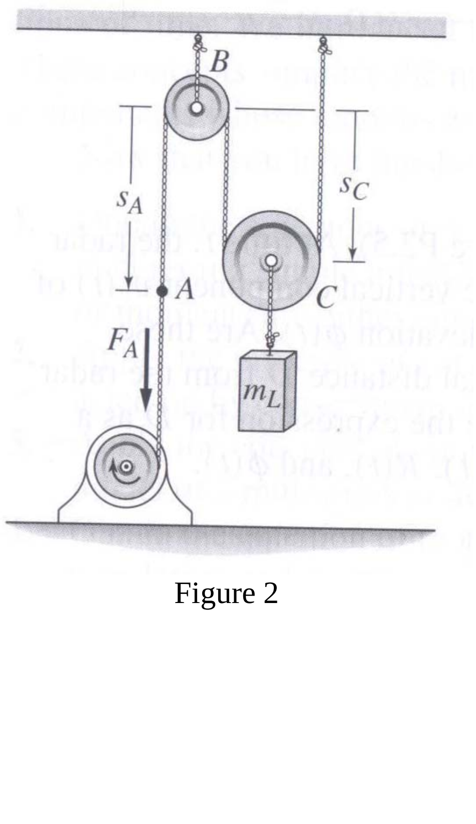


Figure 2

3. **The geared system shown in Figure 3 represents an elevator system. The motor has an inertia $I_1$ and supplies a torque $T_1$. Neglect the inertias of the gears, and assume that the cable does not slip on the pulley. Derive an expression for the equivalent inertia $I_e$ felt on the input shaft (shaft 1). Then derive the dynamic model of the system in terms of the speed $\omega_1$ and the applied torque $T_1$. The pulley radius is $R$.**

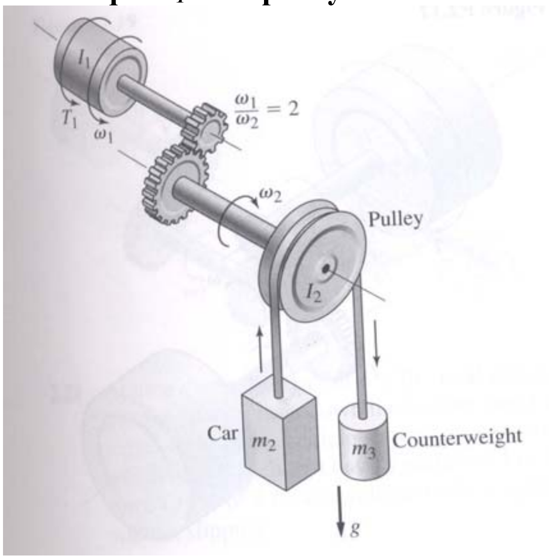


Figure 3

4. **The *lead screw* (also called a *power screw* or a *jack screw*) is used to convert the rotation of a motor shaft into a translational motion of mass $m$ (see Figure 4). For one revolution of the screw, the mass translates a distance $L$ (called the *screw lead*). As felt on the mirror shaft, the translating mass appears as an equivalent inertia. Use kinematic energy equivalence to derive an expression for the equivalent inertia. Let $I_s$ be the inertia of the screw.**

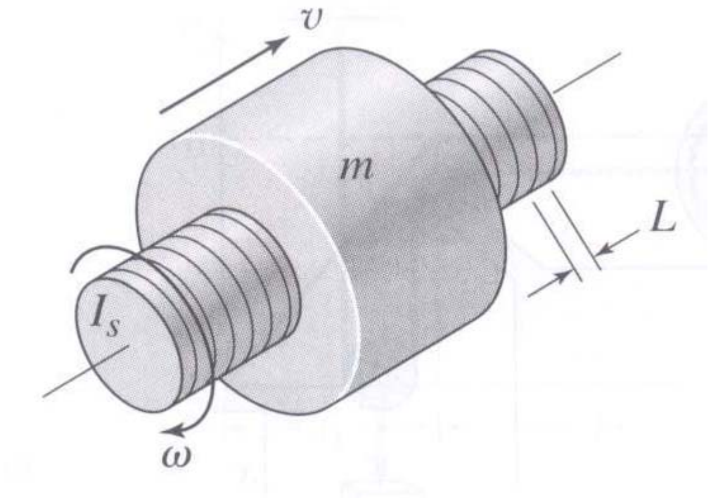


Figure 4

5. **At time $t = 0$, the operator of the road roller disengages the transmission so that the vehicle rolls down the incline (see Figure 5). Derive a dynamic model for the vehicle's speed. The two rear wheels weigh 250 kg each and have a radius of 1 m. The front wheel weighs 400 kg and has a radius of 0.5 m. The vehicle body weights 4500 kg. Assume the wheels roll without slipping.**

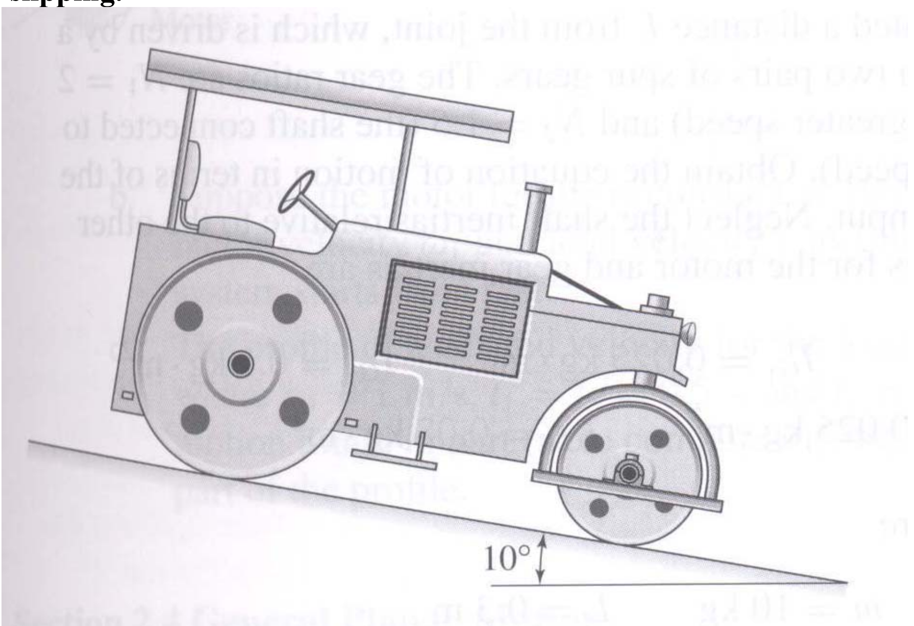


Figure 5

6. **A conveyor drive system to produce translation of the load is shown in Figure 6-(a). The redactor is a gear pair that reduces the motor speed by a factor of 10:1. The motor inertia is $I_1 = 0.002$ kg·m$^2$. The redactor inertia as felt on the motor shaft is $I_2 = 0.003$ kg·m$^2$. Neglect the inertia of the tachometer, which is used to measure the speed for control purposes. The properties of the remaining elements are given here.**

   **Sprockets:**
   **Sprocket 1: radius = 0.05 m weight = 9 N**
   **Sprocket 2: radius = 0.15 m weight = 89 N**
   **Chain weight: 107 N**
   **Drive shaft: radius = 0.04m weight = 22N**
   **Drive wheels (four of them): radius = 0.2 m weight = 89 N**
   **Drive chains (two of them): weight = 670 N each**
   **Load friction torque measured at the drive shaft: 54 N·m**
   **Load weight: 450 N**

   a. **Derive the equation of motion of the conveyor in terms of the motor velocity $\omega_1$, with the motor torque $T_1$ as input.**
   b. **Suppose the motor torque is constant at 10N·m. Determine the resulting motor velocity $\omega_1$ and load velocity v as functions of time, assuming the system starts from rest.**
   c. **The profile of a desired velocity for the load is shown in Figure 6-(b), where $v_0 = 1$ m/s, $t_1 = t_3 = 0.5$ s, and $t_2 = 2$ s. Use the equation of motion found in part (a) to compute the required motor torque for each part of the profile.**

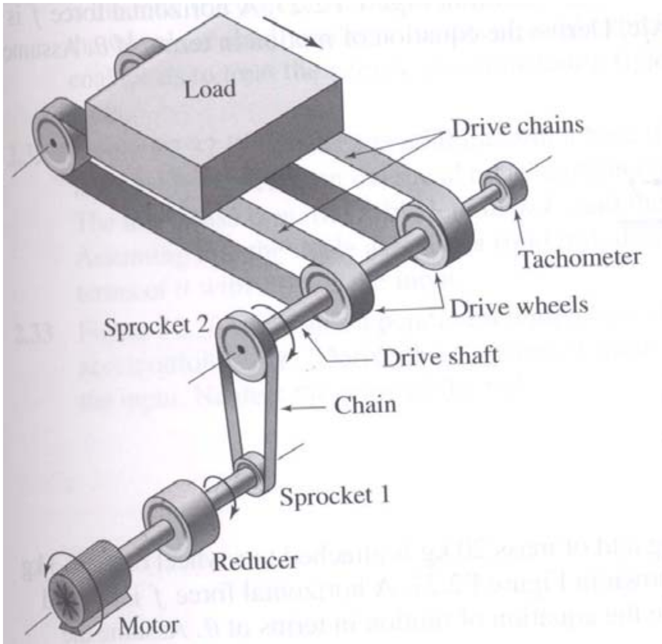


Figure 6-(a)

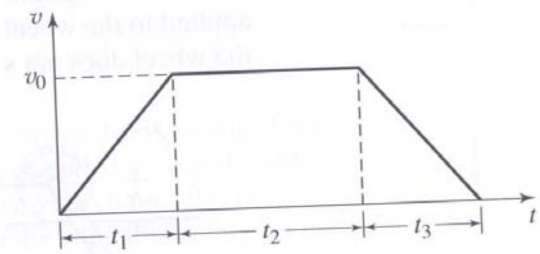


Figure 6-(b)

**7. The vehicle operates with shaft torque $T_s$ and brake torque $T_b$. Derive a dynamic model for vehicle. (Use some assumptions and coefficients if it needed)**

**Input:** $u_1 = T_s, u_2 = T_b$,

**State:** $x = \text{distance}$

$\dot{x} = velocity$

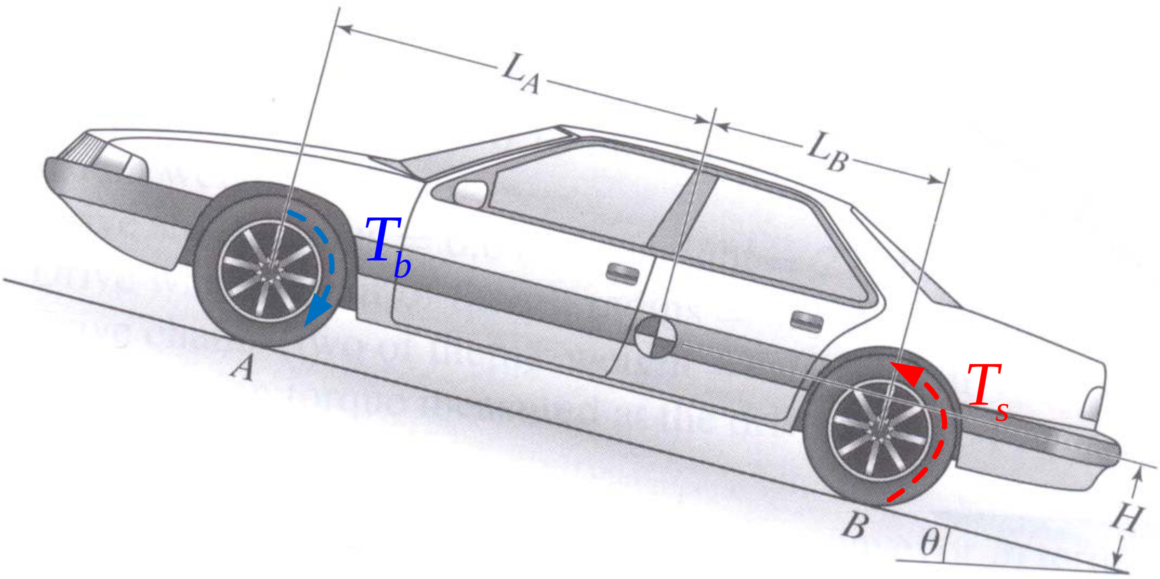


Figure 7