Problem 1.
For the op-amp in Figure P2.2 (b) of Text (see figure on next page), derive the transfer function between input voltage $v_i$ and output voltage $v_0$.

Problem 2.
For the electric motor in P2.25 of Text (see figure on next page), derive the transfer function between input variable $\theta_m$ and output variable $\theta_i$.

Problem 3.
For the system shown below, find the transfer function for $r_1$ as input and $\theta_3$ as output.

Problem 4.
The dynamics of a car is described by the following equation

$$F - F_d - F_f = m\ddot{v}$$

where $F$ is the driving force generated by the engine, $F_d$ is the force due to wind drag, $F_f$ is the friction force acting on the tires, and $v$ is the velocity of the car. The drag force and the friction force can be modeled as

$$F_d = K_d\dot{v}^2, \quad F_f = K_f v$$

where $K_d \approx 1.1 \text{ N s}^2/\text{m}^2$ and $K_f \approx 0.095 \text{ N s/m}$. If the mass of the car is 1050 kg, find the transfer function for $F$ as input and $v$ as output at the operating velocity of $v = v_0 = 40 \text{ m/s}$. 
FIGURE P2.2

FIGURE P2.25