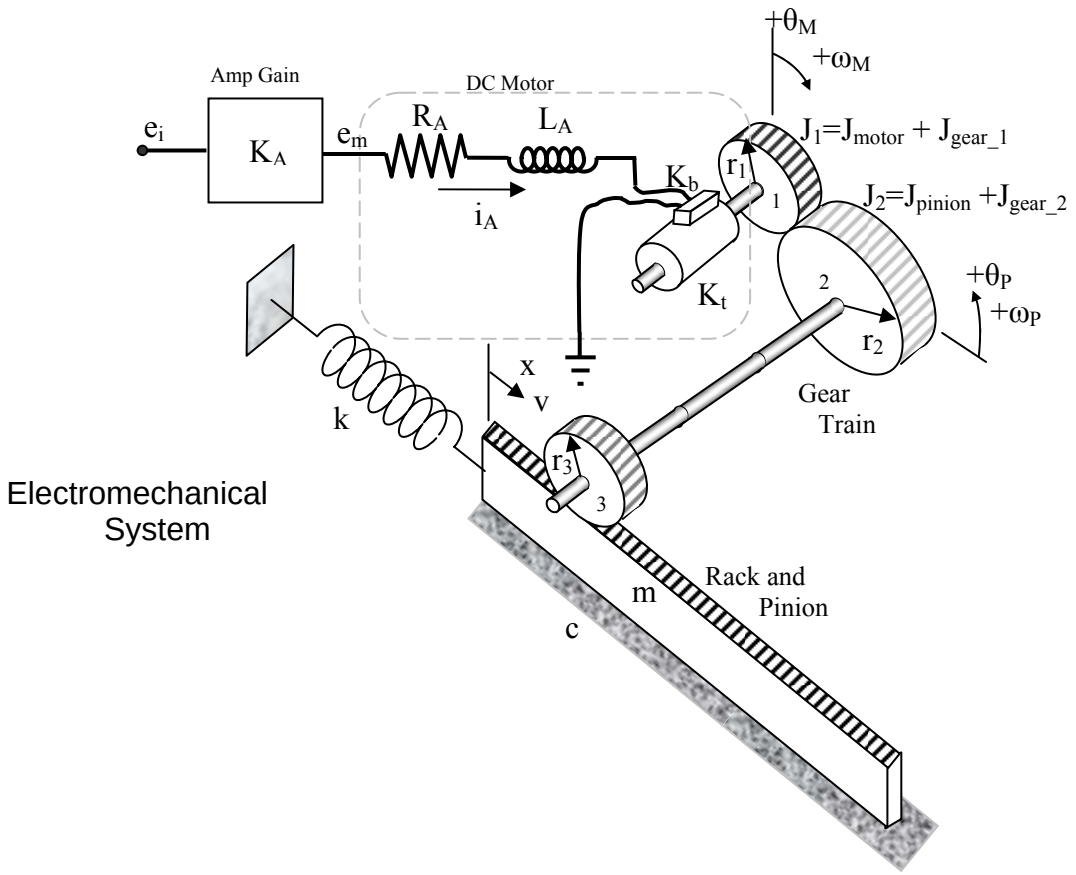
Lesson 10

Problem 10.1

Find the system model for the electromechanical system below. Express the model as a set of three 1st-order differential equations of the form

$$\frac{di_A}{dt} = \_\_\_\_\_$$
$$\frac{dx}{dt} = \_\_\_\_\_$$
$$\frac{dv}{dt} = \_\_\_\_\_$$

These first-order equations are to be expressed in terms of the parameters K_A, R_A, L_A, K_b, K_t, J_1, J_2, r_1, r_2, r_3, m, c, and k, the three state variables i_A, x, and v, the input variable e_i, and time t. Hint: Express θ_M and θ_P as a function of x and express α_M and α_P as a function of $\ddot{x}$.



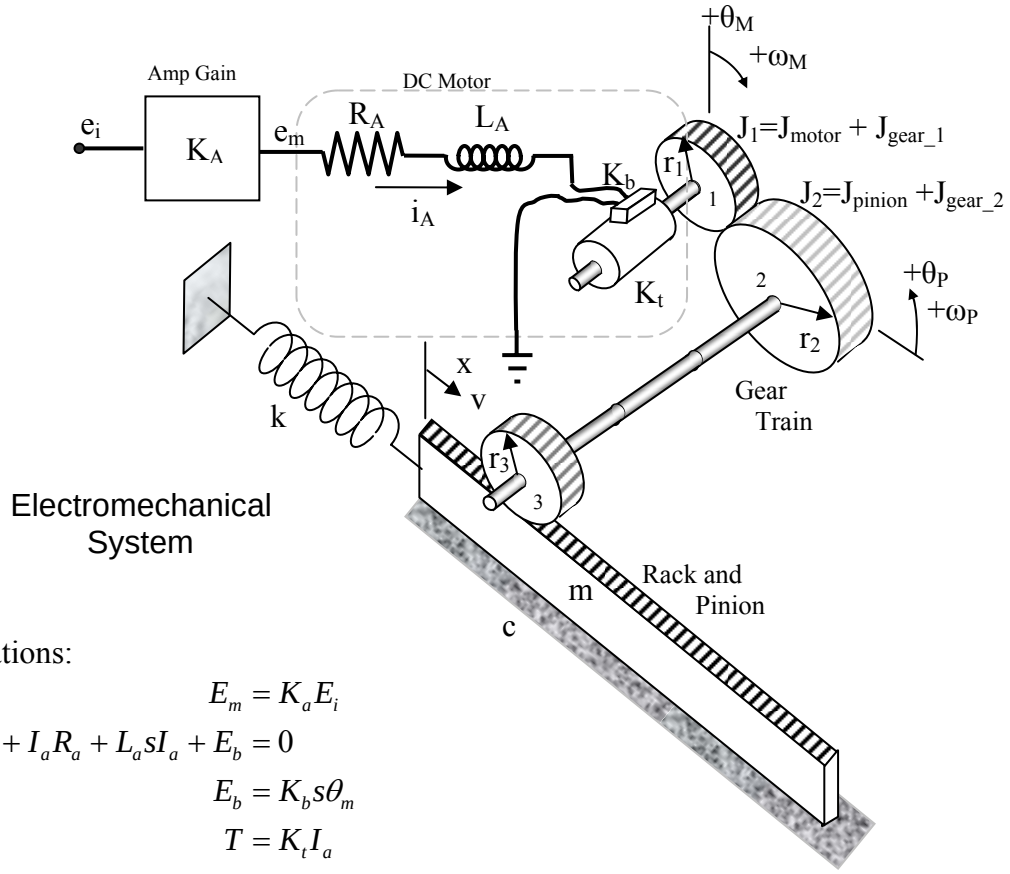
Electromechanical System

Problem 10.2

Draw a block diagram for the system shown below. Do not use the differential equations derived in problem 8.1, but use the equations of the various components which are given below. Note that F_1 is the force acting between the two gears and F_2 is the force acting between the rack and the pinion. *Do not use differentiation blocks*.

Hint 1: The $J_1\ddot{\theta}_m$ and $J_p\ddot{\theta}_p$ terms are both in negative feedback loops to summing blocks.

Hint 2: To avoid differentiation blocks, solve the EOM of the rack for $\ddot{x}$, the motor shaft for F_1 and the rack and pinion for F_2.



Electromechanical System

Equations:

$$E_m = K_a E_i$$

$$-E_m + I_a R_a + L_a s I_a + E_b = 0$$

$$E_b = K_b s\theta_m$$

$$T = K_t I_a$$

$$J_1 s^2\theta_m + F_1 r_1 = T$$

$$J_2 s^2\theta_p + F_2 r_3 = F_1 r_2$$

$$ms^2 X + csX + kX = F_2$$

$$r_1\theta_m = r_2\theta_p$$

$$x = r_3\theta_p$$