Carleton University
Dept. of Systems and Computer Engineering
Systems and Simulations—SYSC 3600 Fall 2014

Homework #7

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1. The grear train system shown in Figure 1 is driven by the electric motor shown. The field current is held constant and the armature coil inductance is negligble. At time $t = 0$ a DC voltage of 10 volts was applied to the motor terminals. Derive an expression for the output rotation $\theta_1(t)$ and $\theta_2(t)$. Use the following parameters.
   - $e_a(t) = 10u(t)$
   - The constant relating the armature current to the motor torque is $K_a = 10$ Nt.m/Ampere.
   - The constant relating angular velocity to the motor back emf is $K_b = 3$ V.s.
   - $b_1 = b_2 = b_3 = b_4 = 2$ Nt.s/m
   - $J_1 = J_2 = 2$ Nt.m.s^2
   - $J_3 = J_4 = 1$ Nt.m.s^2
   - $R_a = 5$ Ohm
   - $r_1 = r_4 = r_6 = 0.5$ m
   - $r_2 = r_3 = 0.10$ m
   - $r_5 = 0.35$ m

2. The system shown in Figure 2 is used to transform rotational movement to a translational one. The motor shaft is connected to a gear (that I had difficulty plotting) and the gear teeth engage a teethed bar that can slide freely without friction over the rollers. The field current of the electric motor is fixed and its armature inductance is negligble. The output of the system is the displacement of the mass m. Find the transfer function $X(s)/E_a(s)$. Use the following parameters.
   - $k_1 = k_2 = 1$ Nt./m
   - $m = 2$ Kg
   - $r = 0.25$ m
   - $R_a = 2$ Ohm
   - $J = 2$ Nt.m.s^2
   - The constant relating the armature current to the motor torque is $K_a = 10$ Nt.m/Ampere.
   - The constant relating angular velocity to the motor back emf is $K_b = 2$ V.s.
   - $b = 1$ Nt.s/m

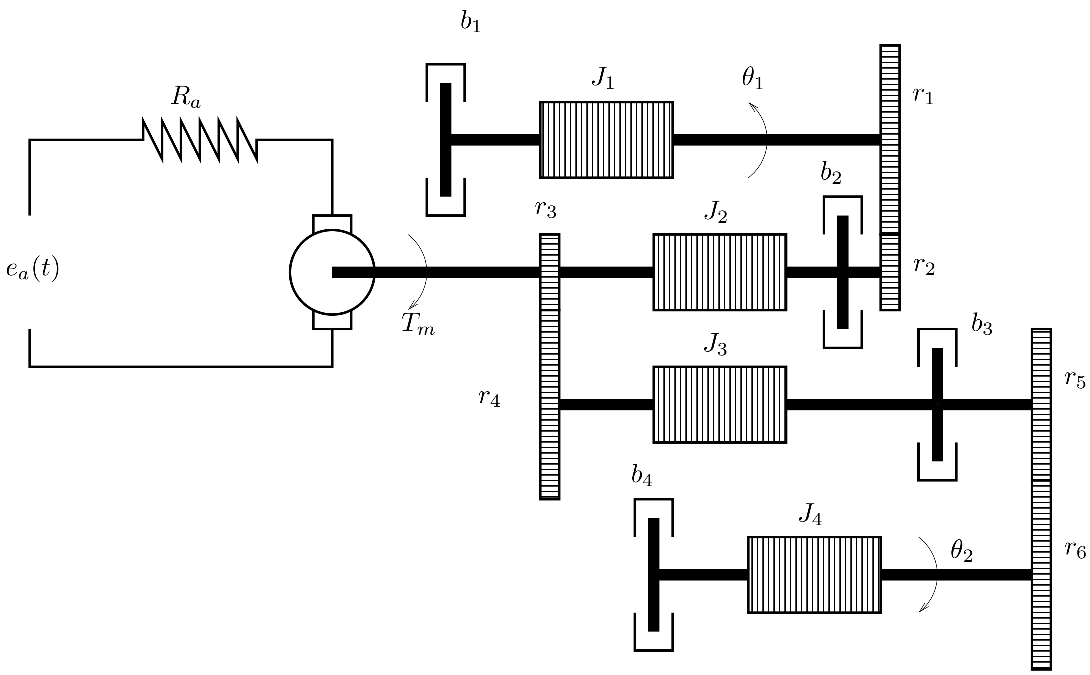

Figure 1: Train gear system.

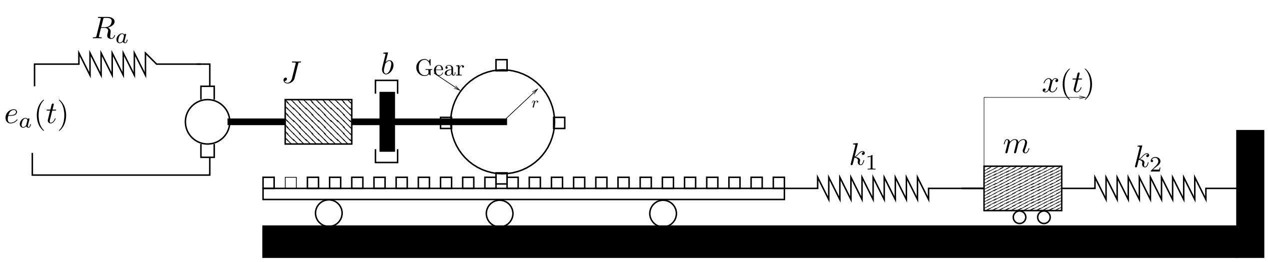

Figure 2: Mechanism for transforming rotational to translational motion