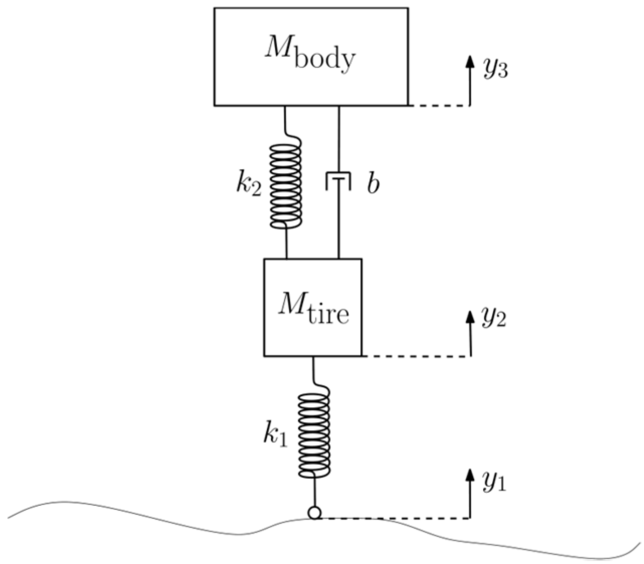
EE302 HW1 **Due Date: 13.03.2018 Tuesday Time: 23:55**

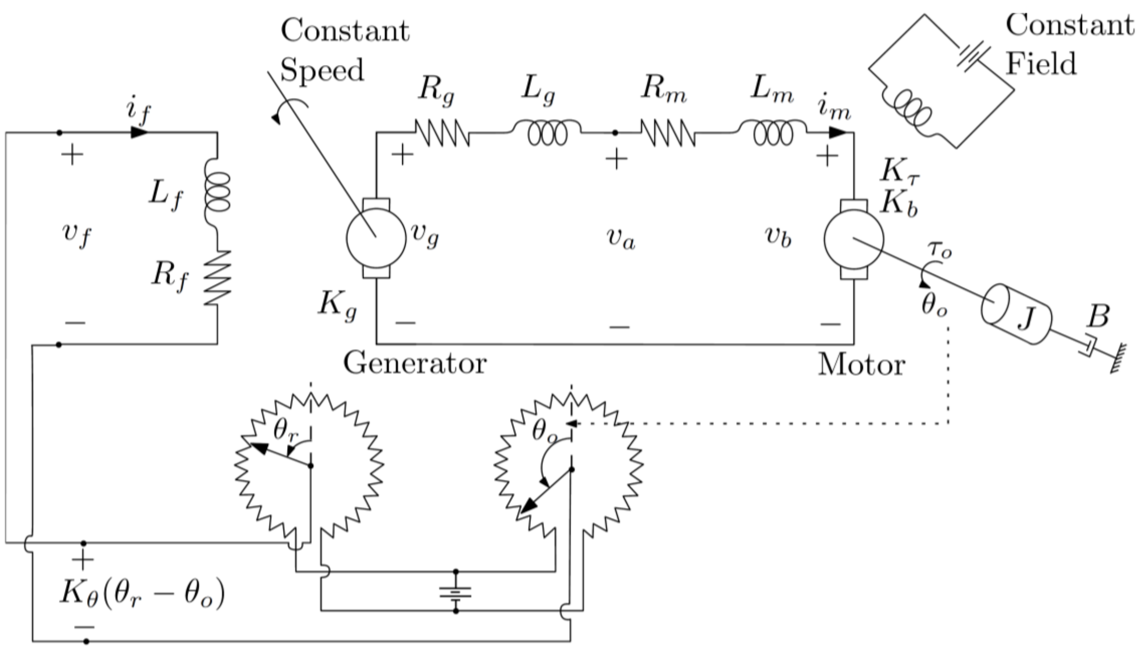
Q1. The aim of this question is to form a mathematical model of the automotive suspension system shown in the figure on the right. We model the tire with a spring with spring coefficient k_1 and a mass M_{tire}. The suspension is composed of a spring with the spring coefficient k_2 and the shock absorber of friction coefficient b which support the mass M_{body} of car's body.



a. Assuming an environment without gravitation, obtain the transfer function of the suspension system given as $\frac{Y_3(s)}{Y_1(s)}$.

b. Find a state-space representation for the suspension system.

Q2. Consider the angular position control system shown in the figure below.



The reference input θ_r (input of the system) is compared with the output angular position θ_o (output of the system) using a rotational potentiometer that has a constant K_θ. The voltage difference that the potentiometer supplies is used to feed the field of a DC generator that is driven with a constant speed. The voltage $v_g$the generator produces is related to the field current i_f as $v_g = K_g i_f$. The generator supplies power to an armature controlled DC motor that drives a load of mass J subject to some friction.

a. Draw the block diagram for the angular position control system by identifying the quantities θ_r, θ_o, v_f,i_f v_g, v_b, v_g, i_m, τ_o on the block diagram.

b. Reduce the block diagram and obtain the overall transfer function $\frac{\Theta_o(s)}{\Theta_r(s)}$ for the angular position control system.

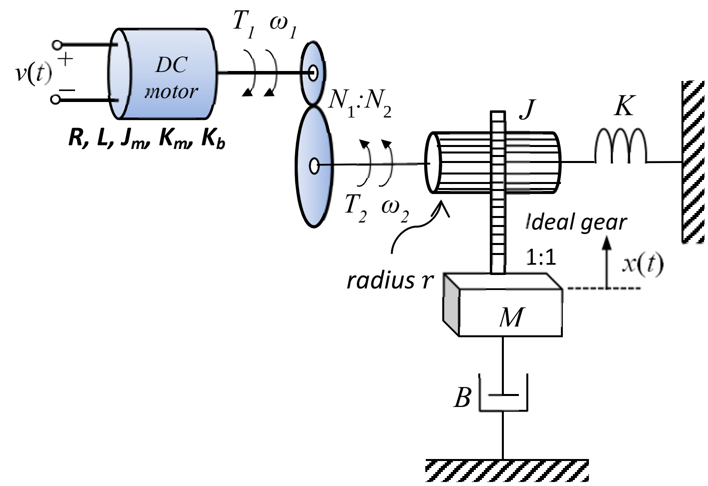
c. What is the minimum number of state variables you need to use to obtain a state-space representation for this system?

d. Among the alternatives below, which state definition is suitable for obtaining a state-space representation for this system? Explain why the others are not suitable. Using the suitable the state vector definition, find the state-space representation of the system.

i. $x = \begin{bmatrix} i_f & i_m & \theta_r & \dot{\theta}_r \end{bmatrix}^T$ ii. $x = \begin{bmatrix} i_f & i_m & \theta_0 & \dot{\theta}_0 \end{bmatrix}^T$

iii. $x = \begin{bmatrix} i_f & i_m & \dot{\theta}_0 & \ddot{\theta}_0 \end{bmatrix}^T$ iv. $x = [i_f \quad i_m \quad \tau_0 \quad \theta_0]^T$

Q3. Consider the electro-mechanical system illustrated on the right.



In the system, we have an armature controlled DC motor with armature resistance *R* and inductance *L*. The rotor inertia of the motor is J_m while the torque and back emf constants are K_m and K_b respectively. The friction of the rotor is neglected. *B* is the damping coefficient for a viscous friction damper and *K* is the spring constant. All other parameters of the system are given in the figure. The system input is the DC motor input voltage $v(t)$ and the system output is the mass displacement $x(t)$. Note that forces f can be converted to torques τ involving the ideal gear using the equation $\tau = fr$ where r is the radius.

a. Obtain the mathematical model of the system by writing individual terminal equations for all components (Neglect the gravity).

b. Obtain a detailed block diagram of the system.

c. Find the overall transfer function of the system.

Q4. Solve Question 9 at the end of Chapter 5 of Nise (6th Edition) which is shown on the right.

9. Reduce the block diagram shown in Figure P5.9 to a single transfer function, $T(s) = C(s)/R(s)$. [Section: 5.2]

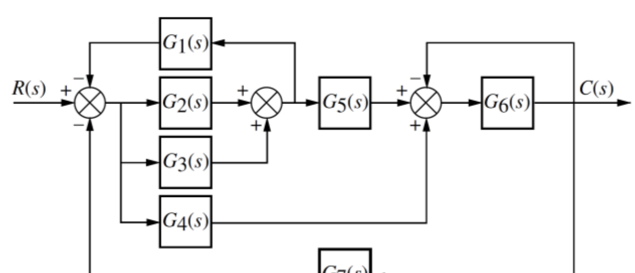


FIGURE P5.9