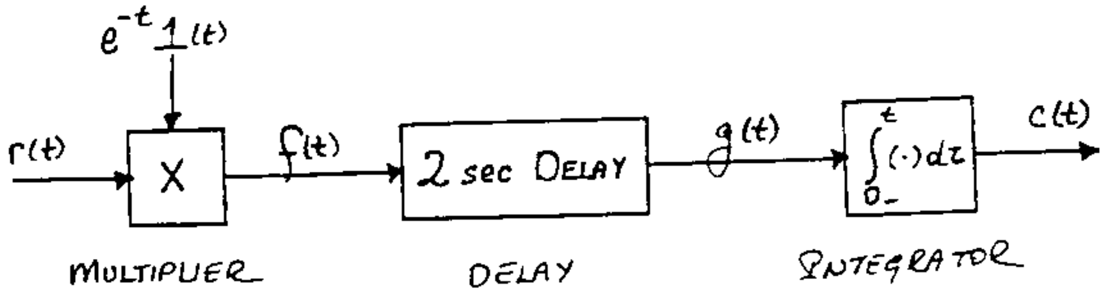
EE 231 | Exam#1 | Sept. 19, 1989

75 minutes

1. For the following simulation diagram

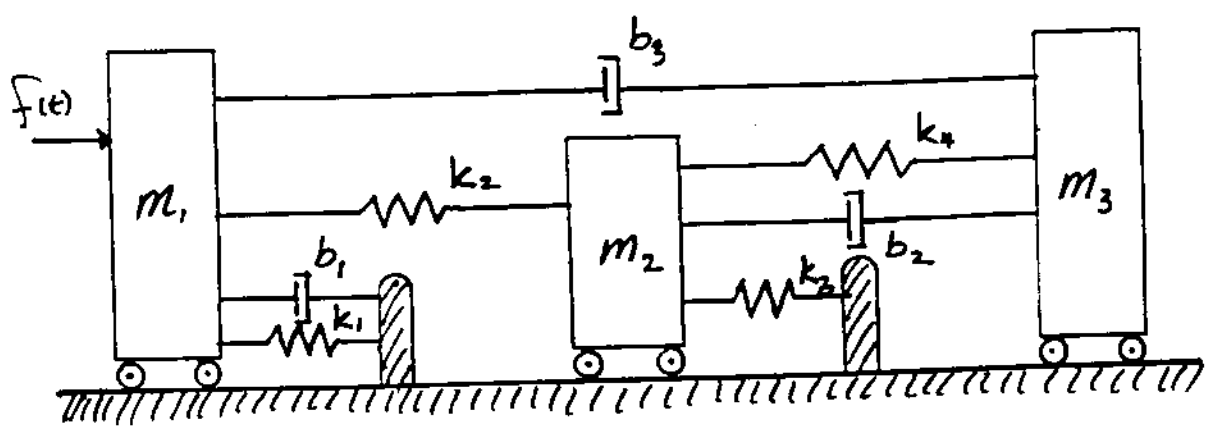


determine the input signal $r(t)$, where $\mathcal{L}[c(t)] = \frac{3e^{-2s}}{s[(s+1)^2+9]}$. (15 pts)

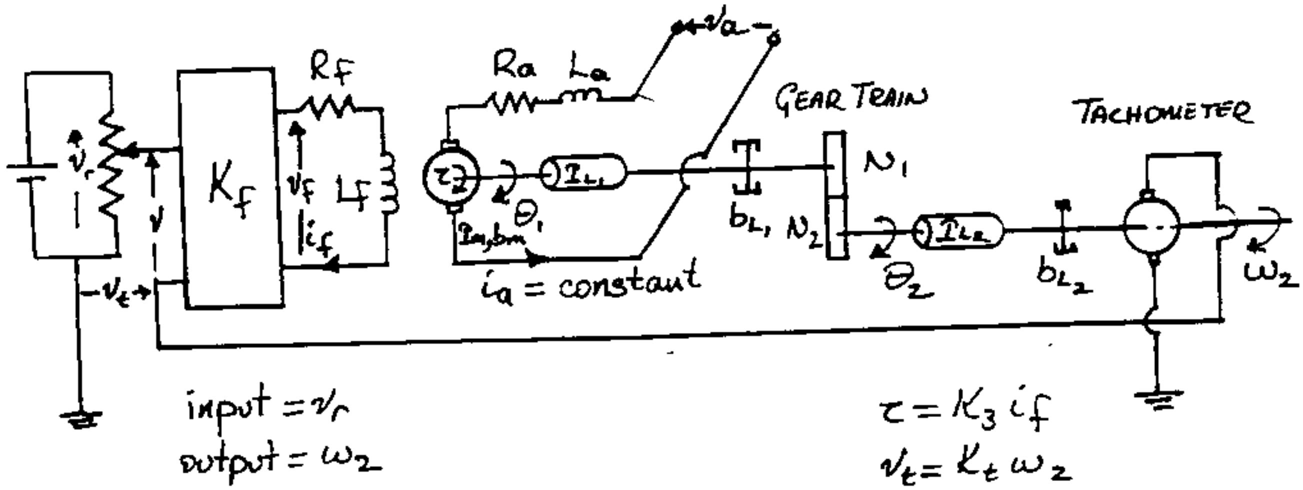
2. For the mechanical system shown below.

   (a) find the differential equations describing the motion of the masses. and (10 pts)

   (b) obtain the force-voltage *or* force-current analog of the system. (10 pts)



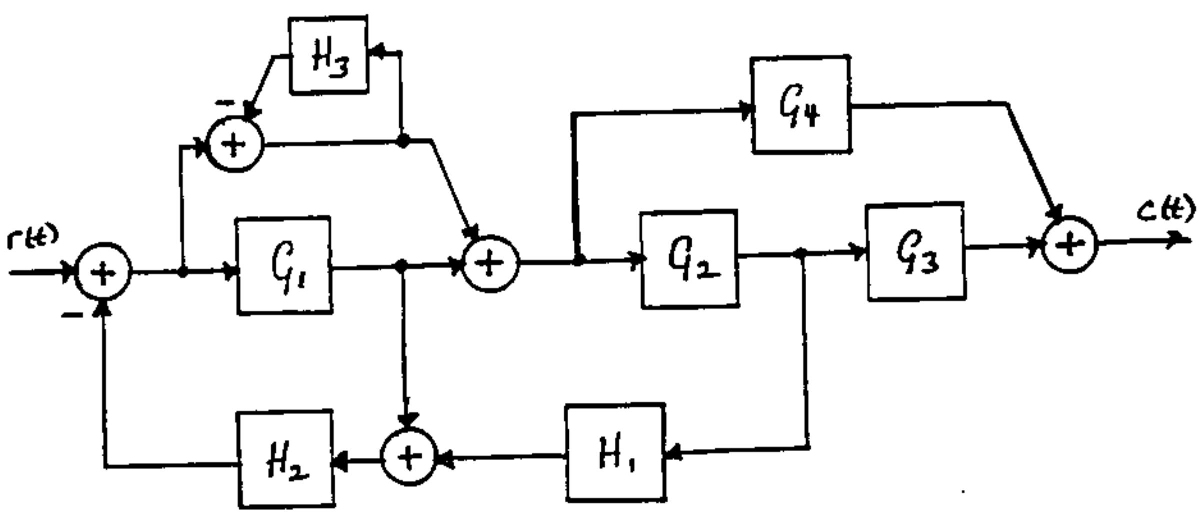
3. A speed control system is shown below. The speed of the motor is detected by a tachometer which gives an output voltage v_t proportional to the output speed ω. This voltage is fed back to the input to create an error voltage which is applied to the field windings of a dc motor. The load consists of the motor load (I_m, b_m), an external load (I_{L_1}, b_{L_1}) and another external load (I_{L_2}, b_{L_2}) after a gear train. Write the individual equations describing the system and obtain a detailed block diagram from these equations. (25 pts)



4. For the block diagram given below,

(a) determine the transfer function by block diagram reduction, and (25 pts)

(b) draw the equivalent signal flow diagram and determine all the forward paths and loops. Also classify the nontouching loops. (15 pts)



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#1 $r(t) = \sin 3t\, 1(t)$; $F(s) = \dfrac{3}{(s+1)^2+9}$

$$G(s) = \frac{3e^{-2s}}{(s+1)^2+9}$$

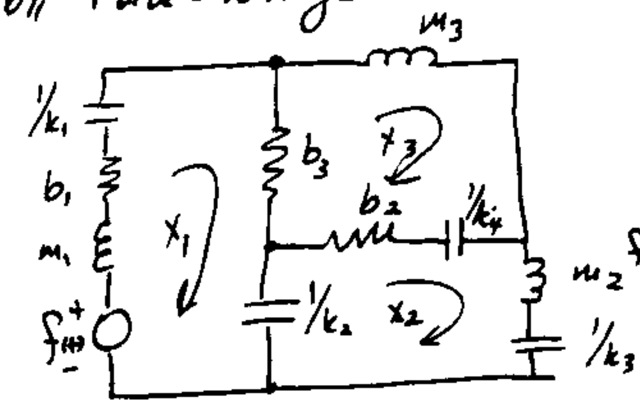
#2 a)

$$m_1\ddot{x}_1 = f - b_1\dot{x}_1 - k_1x_1 - k_2(x_1-x_2) - b_3(\dot{x}_1-\dot{x}_3)$$

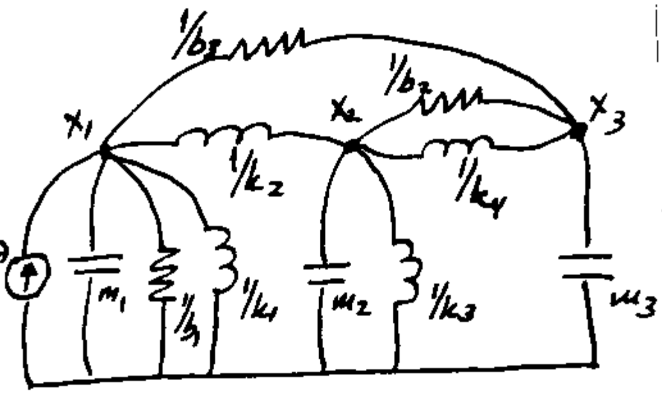
$$m_2\ddot{x}_2 = -k_3x_2 - k_2(x_2-x_1) - b_2(\dot{x}_2-\dot{x}_3) - k_4(x_2-x_3)$$

$$m_3\ddot{x}_3 = -b_3(\dot{x}_3-\dot{x}_1) - b_2(\dot{x}_3-\dot{x}_2) - k_4(x_3-x_2)$$

b) Force-voltage



Force-current



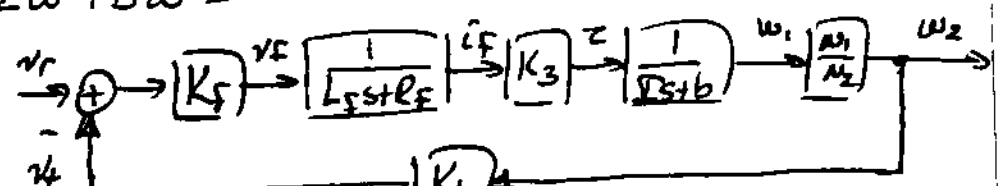
#3

$\tau = K_3 i_f$ $\quad v_f = K_f(v_r - v_t)$ $\quad \mathcal{J} = \mathcal{J}_m + \mathcal{J}_{L_1} + \left(\frac{N_1}{N_2}\right)^2 \mathcal{J}_{L_2}$

$v_t = K_t\omega_2$ $\quad v_f = L_f \dot{i}_f + R_f i_f$ $\quad b = b_m + b_{L_1} + \left(\frac{N_1}{N_2}\right)^2 b_{L_2}$

$\mathcal{J}\dot{\omega} + b\omega = \tau$

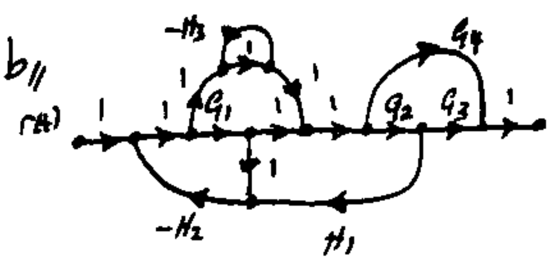
$\omega_2 = \dfrac{N_1}{N_2}\omega_1$



#4 a)

$$\frac{C(s)}{R(s)} = \frac{(1+G_1+G_1H_3)(G_2G_3+G_4)}{(1+G_1H_2)(1+H_3)+G_2H_1H_2(1+G_1+G_1H_3)}$$

b)



FORWARD PATHS : $F_1 = G_1G_2G_3$
$F_2 = G_2G_3$
$F_3 = G_1G_4$
$F_4 = G_4$

LOOPS : $L_1 = -H_3$
$L_2 = -G_1H_2$
$L_3 = -G_1G_2H_1H_2$
$L_4 = -G_2H_1H_2$

NONTOUCHING LOOPS: $L_1 \& L_2$, $L_1 \& L_3$