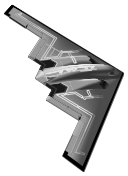
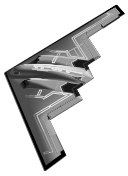
O K L A H O M A S T A T E U N I V E R S I T Y

SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING



ECEN 3723 Systems I
Fall 2010
Midterm Exam #2
December 2, 2010

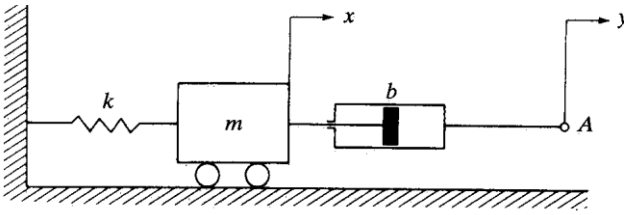


Choose any four out of five problems.
Please specify which four listed below to be graded:
1)_____; 2)_____; 3)_____; 4)_____;

Name : _____

E-Mail Address:_____

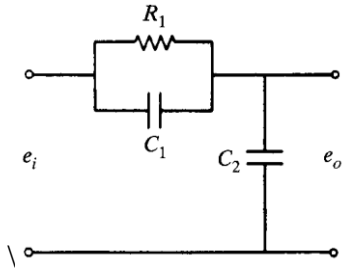
Problem 1: The mechanical system shown below is at rest initially. At $t = 0$, a unit-step displacement input is applied to point *A* (i.e., $y(t) = u(t)$). Assuming that the system remains linear throughout the response period and is *underdamped*, determine the response $x(t)$ as well as the values of $x(0+)$, $\dot{x}(0+)$ and $x(\infty)$.



Problem 2: Derive the transfer function $E_o(s)/E_i(s)$ of the electrical circuit shown below. The input voltage is a pulse signal given by

$$e_i(t) = \begin{cases} 10 \text{ Volt}, & 0 \le t \le 5 \\ 0, & \text{elsewhere} \end{cases}.$$

Obtain the output $e_o(t)$. Assume that the initial charges in the capacitors C_1 and C_2 are zeros. Assume also that $C_2 = 1.5C_1$ and $R_1C_1 = 1$ second.



Problem 3: The block diagram of an electric train is shown below. The system parameters and variables are

$e_r(t)$ = voltage representing the desired train speed, V

$v(t)$ = speed of train, ft/sec

M = mass of train = 30,000 lb/sec^2

K = amplifier gain

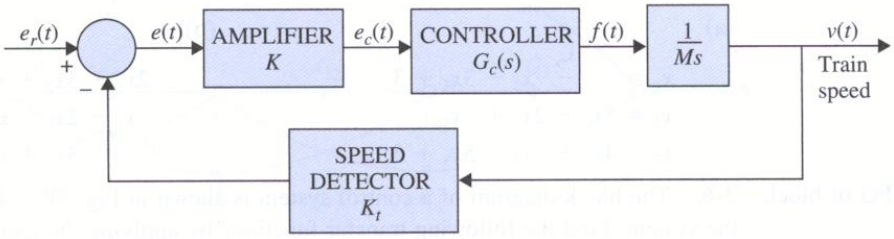
K_t = gain of speed indicator = 0.15 V/ft/sec

To determine the transfer function of the controller, we apply a step function of 1 volt to the input of the controller, that is $e_c(t) = u(t)$. The output of the controller is measured and described by $f(t) = 100(1 - 0.3e^{-6t} - 0.7e^{-10t})u(t)$.

a) Find the transfer function of the controller, $G_c(s)$.

b) Derive the closed-loop transfer function of the system, $V(s)/E_r(s)$

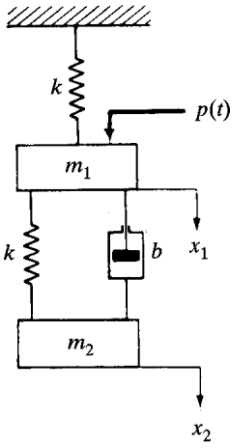
c) Assuming that K is set at a value so that the train will not run away (unstable), find the steady-state speed of the train in feet per second when the input is $e_r(t) = u(t)$ V.



Problem 4: Consider the mechanical system shown below. Obtain the steady state outputs $x_1(t)$ and $x_2(t)$ when the input $p(t)$ is a sinusoidal force given by

$p(t) = P_1 \sin \omega_1 t + P_2 \sin \omega_2 t$.

The output displacements $x_1(t)$ and $x_2(t)$ are measured from the respective equilibrium positions.



Problem 5: Using the block diagram reduction technique, find the closed-loop transfer function, $H(s) = \frac{Y(s)}{U(s)}$.