SEOUL NATIONAL UNIVERSITY
SCHOOL OF MECHANICAL AND AEROSPACE ENGINEERING

SYSTEM ANALYSIS **Spring 2008**

Final Exam **Date: June 10, 2008 (tu)**
Closed book, closed note **10:30~11:55AM**

Student ID #: ________________ Name: _______________________

Problem No (points)	Points
1(20)	
2(15)	
3(20)	
4(10)	
5(10)	
6(10)	
Total(85)	

[1] (20 points) Describe followings:

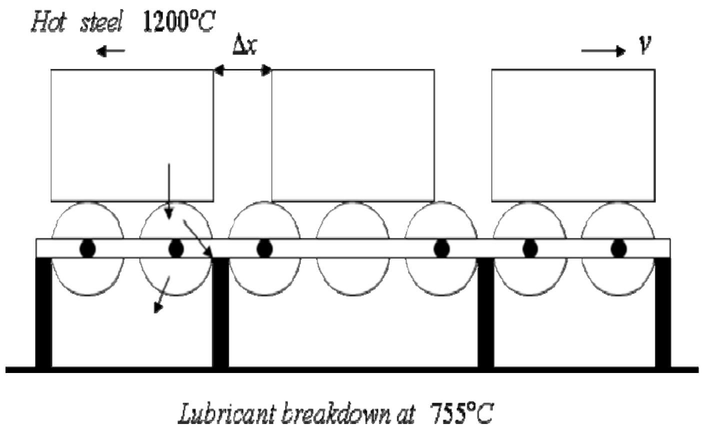
(1) Linear dynamic systems

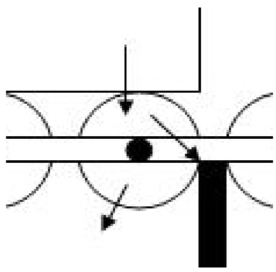
(2) Solution of the State equation: $\dot{x}(t) = Ax(t) + Bu(t), \quad x(0) = x_0$

(3) Frequency response and bode plots

(4) System Design

[2] (15 points) Consider a hot steel processing plant shown below. The temperature of the hot steel slab, T_s, is 1200 degree. Ambient air temperature, T_A, is 30 degree. The thermal resistance, R_1, for heat transfer between the hot steel slab and the roller is 10 $\frac{^oC}{kcal/s}$. The thermal resistance, R_2, for heat transfer between the roller and the ambient air is 20 $\frac{^oC}{kcal/s}$. The mass of the roller, m, is 5 Kg and the specific heat of the roller, C_p, is 1 $kcal/[kg\ ^oC]$. The lubricant breakdowns at 755 ^oC.



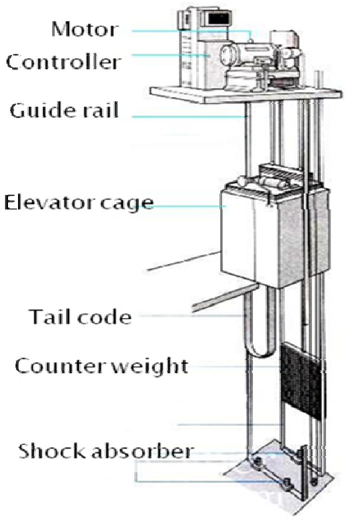


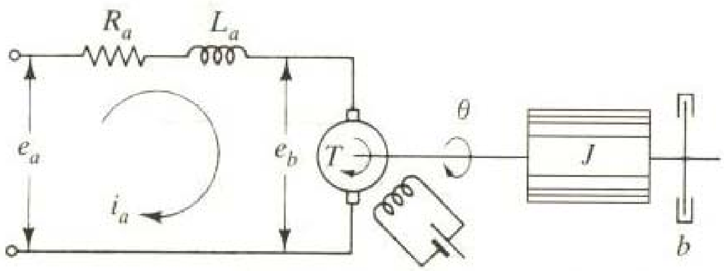
(1) Write down the heat balance equation for the roller.

(2) What is the steady state temperature of the bearing?

(3) What is your solution to avoid the breakdown of the lubricant of the bearing in the roller?

[3] (20 points) Consider an elevator system shown in the figure. The schematic diagram of the elevator system controlled by a DC electric motor is shown below. J is the equivalent moment of inertia of the elevator cage and the motor combined.





(1) Assuming that the armature inductance, L_a, is negligible, derive the equations of motion of the system.

(2) The position of the elevator cage, θ, can be controlled by the voltage input to the motor, e_a.

Obtain the transfer function of the system, i.e., $G(s) = \dfrac{\Theta(s)}{E_a(s)}$ **.**

(3) The velocity of the elevator cage is represented as

$$V_c = R\frac{d\theta}{dt}$$

where R is the equivalent radius of the elevator cage roller. The maximum voltage input of the motor, $e_{a,\max}$, is 300 Volts. What is the maximum speed of the elevator cage?

(4) Assuming that the transfer function between the voltage input to the motor and the angular position of the elevator cage is as follows:

$$\frac{\Theta(s)}{E_a(s)} = \frac{K_m}{s(T_m s+1)}$$

where

$K_m = K/(R_a b + K K_b) = motor\ gain\ constant$

$T_m = R_a J/(R_a b + K K_b) = motor\ time\ constant$

The equivalent radius of the elevator cage roller, R, is 2 meter. The maximum voltage input of the motor, $e_{a,\max}$, is 300 Volts. What is the motor gain constant we need to have so that the maximum speed of the elevator is $30m/\sec$?

[4] (10 points) What are the characteristic parameters for the first order system and second order systems?

[5] (10 points) Consider a mechanical system shown in the Figure. Obtain the steady-state outputs $x_1(t)$ and $x_2(t)$ when the input $p(t)$ is a sinusoidal force given by

$p(t) = P \sin \omega t$

[6] (10 points) Consider a system described by following state equation:

$$\dot{x} = Ax + Bu$$

$$y = Cx$$

where

$A = \begin{bmatrix} 1 & 1 & 2 \\ 0 & 1 & 3 \\ 0 & 0 & 2 \end{bmatrix}$, B= $\begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$, and C=[0 1 0].

The initial condition is: $x(0) = [0\ 2\ 0]^{\mathrm{T}}$ **.**

Compute the output for unit step input.