Duke University
Edmund T. Pratt, Jr. School of Engineering

ECE 141 Spring 2005

Test I

Michael R. Gustafson II

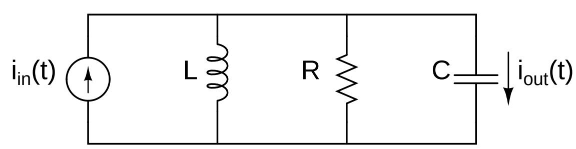
Name (please print)________________________________

In keeping with the Community Standard, I have neither provided nor received any assistance on this test. I understand if it is later determined that I gave or received assistance, I will be brought before the Undergraduate Judicial Board and, if found responsible for academic dishonesty or academic contempt, fail the class. I also understand that I am not allowed to speak to anyone except the instructor about any aspect of this test until the instructor announces it is allowed. I understand if it is later determined that I did speak to another person about the test before the instructor said it was allowed, I will be brought before the Undergraduate Judicial Board and, if found responsible for academic dishonesty or academic contempt, fail the class.

Signature:________________________________

Problem I: [15 pts.] Second-Order Systems

Given the circuit below:



with C=1/9 F, L= 1 H, and $i_{in}(t) = u(t)$ A:

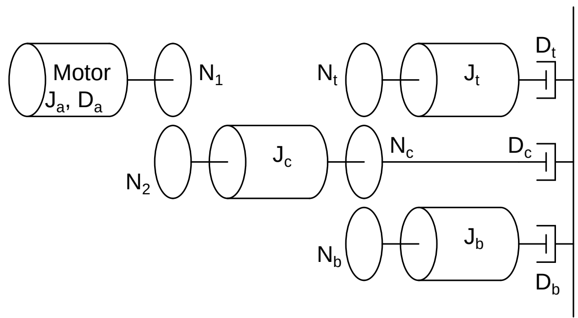
(1) Determine the value of R that represents a critically damped system (call this R_{crit}).

(2) Assuming $R = .6R_{crit}$, determine the natural frequency ω_n, the damping ratio ζ, the damped frequency ω_d, the rise time T_r, the peak time T_p, the settling time T_s, and the percent overshoot $\%OS$ for $i_{out}(t)$.

Name (please print):
Community Standard (print ACPUB ID):

Problem II: [20 pts.] Rotational Transfer Functions

Given the system below,



with

$J_a = 1\text{kg-m}^2$	$J_t = 400\text{kg-m}^2$	$J_c = 40\text{kg-m}^2$	$J_b = 600\text{kg-m}^2$
$D_a = 2\text{N-m s/rad}$	$D_t = 500\text{N-m s/rad}$	$D_c = 30\text{N-m s/rad}$	$D_b = 800\text{N-m s/rad}$
$N_1 = 2$	$N_2 = 4$	$N_t = N_b = 100$	$Nc = 20$

and the knowledge that the relationship of the motor torque to motor speed is:

$$T_m = 750\text{N-m} - (25\text{N-m s/rad})\,\omega_m$$

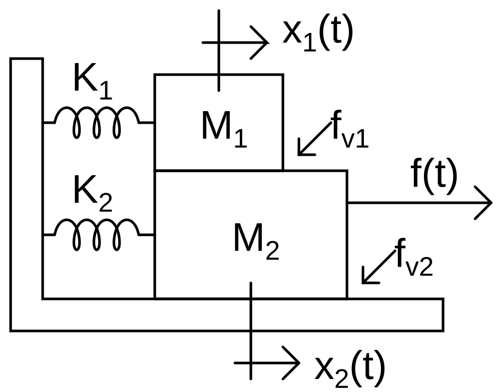
when e_a=10V, determine the transfer function:

$$G(s) = \frac{\Theta_m(s)}{E_a(s)}$$

Name (please print):
Community Standard (print ACPUB ID):

Problem III: [20 pts.] Translational Transfer Functions and State Space

Given the translational system below:



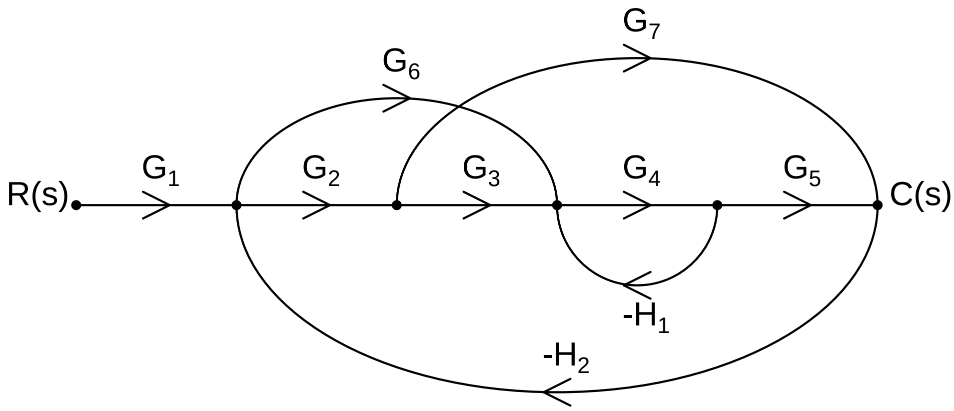
(1) Determine the transfer function $G(s) = X_2(s)/F(s)$. You need to solve for $X_2(s)/F(s)$ but you do not need to multiply things out.

(2) Determine the state space representation of the system if the input is $f(t)$ and the output is $x_1(t)$. Be sure to clearly define all parts of the state space.

Name (please print):
Community Standard (print ACPUB ID):

Problem IV: [15 pts.] Mason's Rule

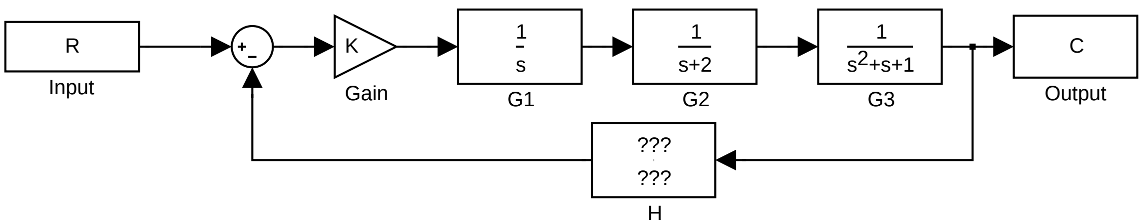
Determine the transfer function $T(s) = C(s)/R(s)$ given the following signal flow graph:



Name (please print):
Community Standard (print ACPUB ID):

Problem V: [30 pts.] Block Diagrams and Stability

Given the block diagram below:



(1) Assuming H=0, determine the overall transfer function, $T_{eq}(s) = C(s)/R(s)$.

(2) Assuming H=0 and K=12, determine the output $c(t)$ when the input $r(t)$ is a unit step function.

(3) Assuming $H = \frac{s}{s+1}$, determine the values of K that produce a stable system.

(4) Assuming $H = \frac{s}{s+1}$, determine the values of K that produce a marginally stable system, and state the corresponding frequencies of oscillation.