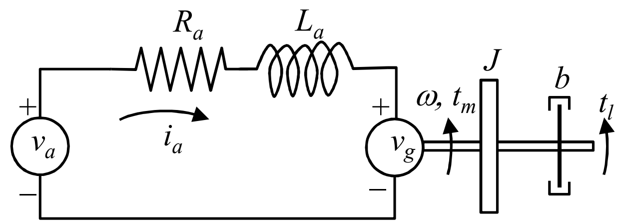
SDC PhD Qualifying Exam
Fall 2013

Work all 4 problems

1.



The figure shows a typical schematic of a DC motor where it is assumed that v_g=$K_g\ \omega$ and t_m=$K_m\ i_a$. It is desired to control the motor speed while under load.

a) Draw the block diagram including labels on the connections.
b) Determine the relevant linear transfer equation without making any further simplifying assumptions.
c) Consider the no load case. Apply the usual simplification and determine a first order transfer equation model.
d) For c) assume that additionally b = 0. Explain whether the system is stable.

v_a – applied voltage
v_g – generator voltage (back EMF)
i_a – armature current
ω – armature speed
t_m – motor torque
t_l – load torque
R_a – armature resistance
L_a – armature inductance
J – armature inertia
b – armature damping
K_m – motor constant
K_g – generator constant

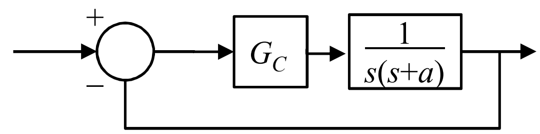
2.

a) A unity feedback system has $KG = K(s+2)/(s-1)^2$. Determine the values of $K > 0$ so the closed-loop response is i) Overdamped. ii) Underdamped.

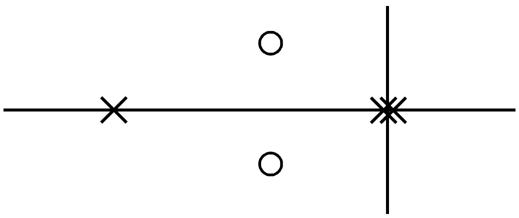
b)-k). The figure shows a unity feedback control of a system with controller G_C. For each of the following:

i) sketch the root-locus

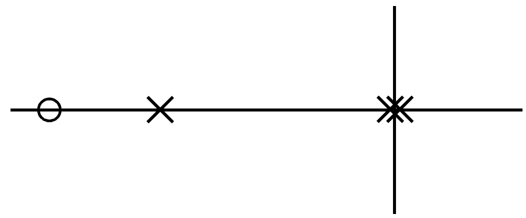
ii) name the type of compensation used.



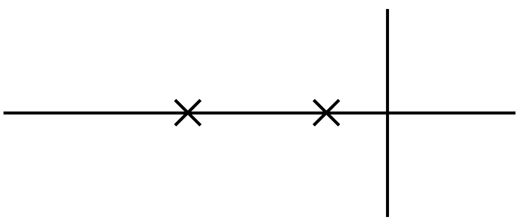
b) assume 1 breakpoint



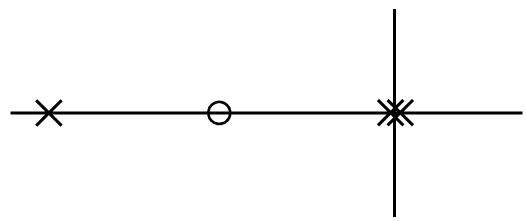
c)



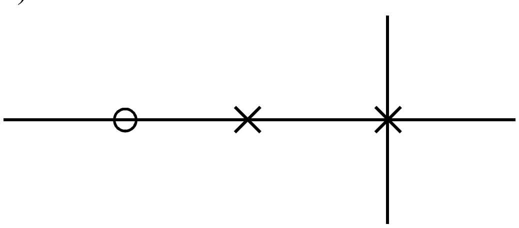
d)



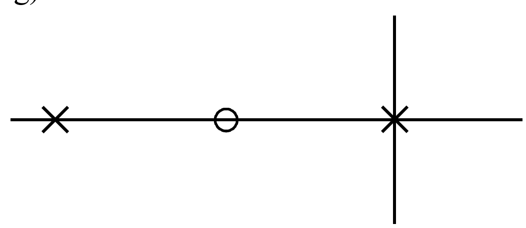
e)



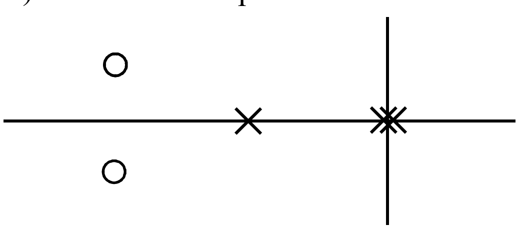
f)



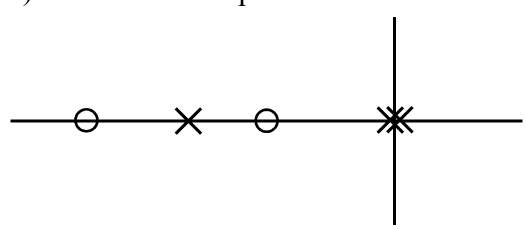
g)



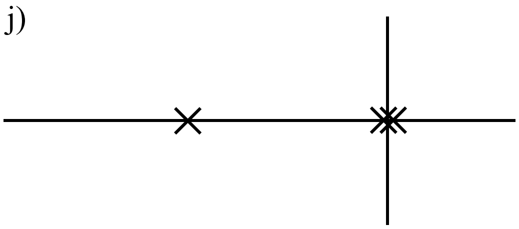
h) assume 3 breakpoints



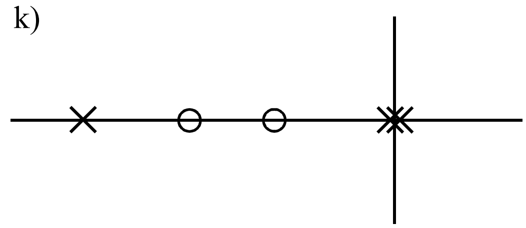
i) assume 2 breakpoints



j)



k)



3.

For the transfer function G = $[s+1/100]/[s(s+1/10)^2]$ *approximate* the following:

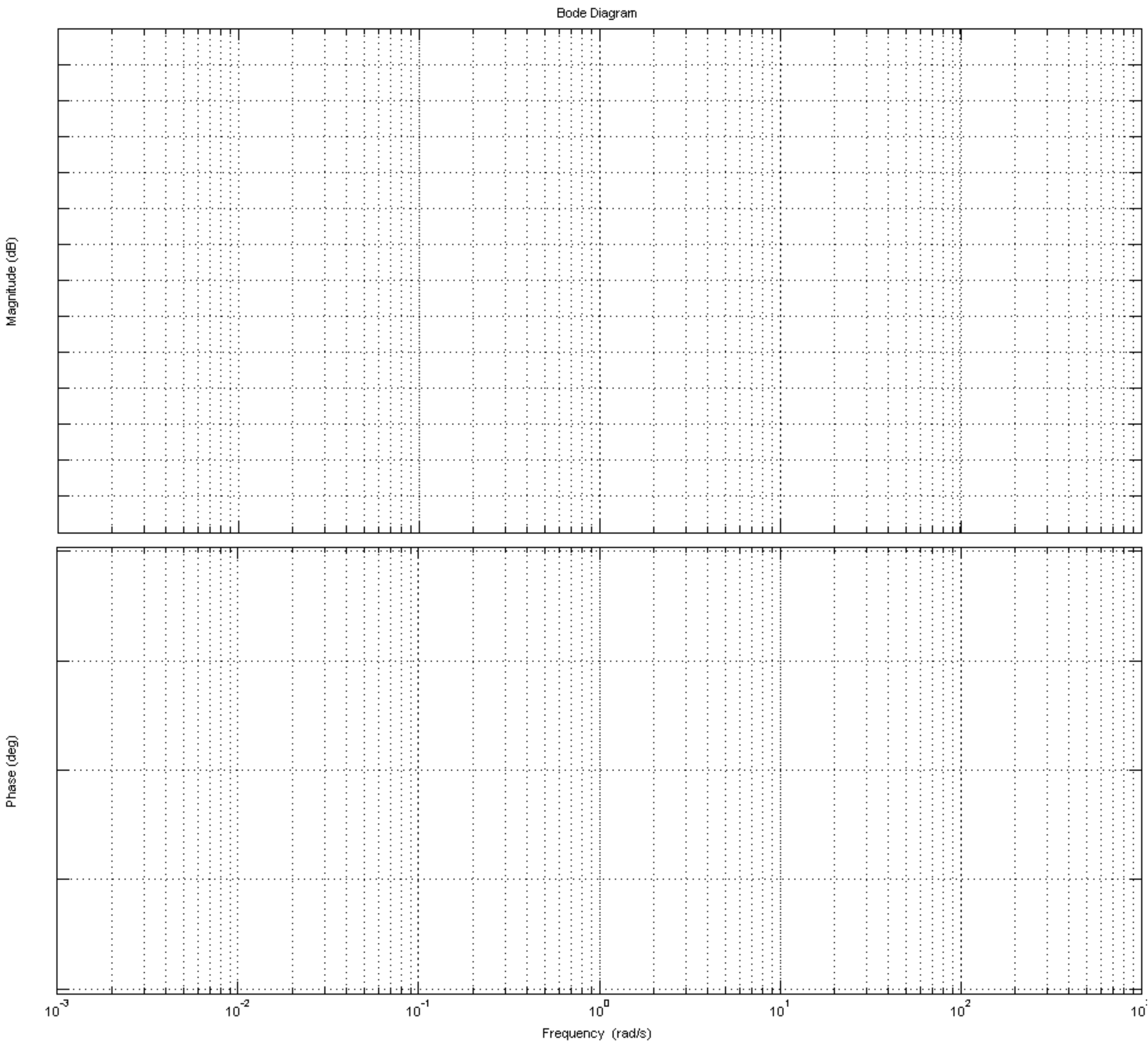
a) Graphs of the magnitude and phase plots (use graphs below)

b) ω_{PC} - the phase crossover frequency

c) PM – the phase margin

d) ω_{GC} - the gain crossover frequency

e) db_{GM}– the gain margin



4.

The following properties are known about a transfer function $F(s)$: .

Property 1: The final value of the unit impulse response of $F(s)$ is 1.
Property 2: $F(s)$ has two poles and one of them is at -2. $F(s)$ has one zero.
Property 3: The unity feedback of $F(s)$ is stable and critically damped.

(a) Determine $F(s)$.
(b) Plot the unit step response of $F(s)$ obtained in (a) versus time. A general sketch without using a calculator is acceptable. You can use the Laplace transformation table given below.

$f(t)$	$F(s)$
Unit impulse $\delta(t)$	1
Unit step $1(t)$	$\frac{1}{s}$
t	$\frac{1}{s^2}$
e^{-at}	$\frac{1}{s+a}$
te^{-at}	$\frac{1}{(s+a)^2}$