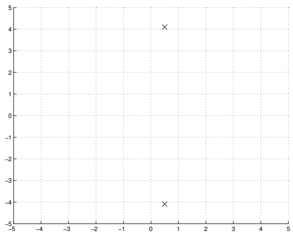
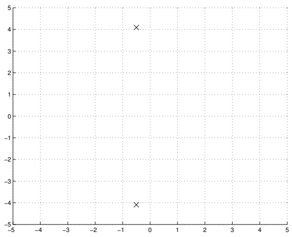
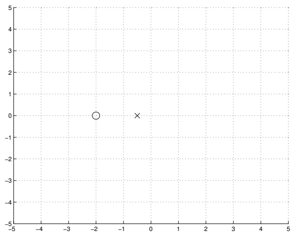
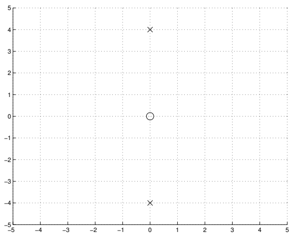
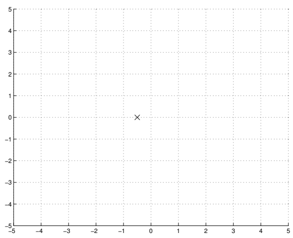
Problem 1
Match each of the following pole-zero diagrams to the corresponding Bode plot and step response from the following two pages. For example is you think that pole-zero diagram (1) corresponds to step response (q) and Bode plot (r), write "1,q,r" on your exam paper.

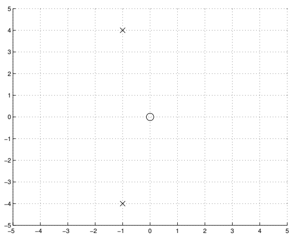


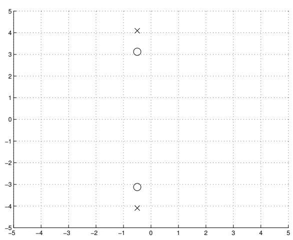


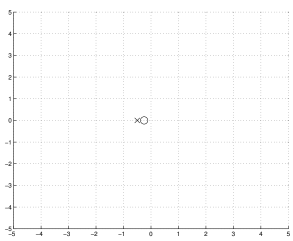


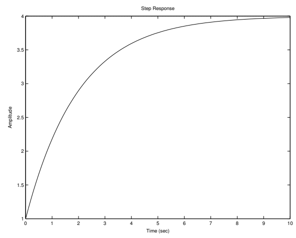


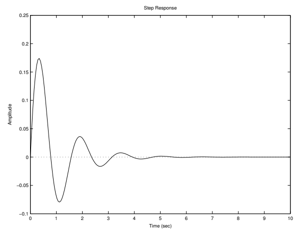


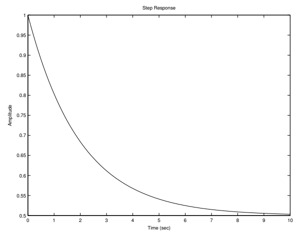


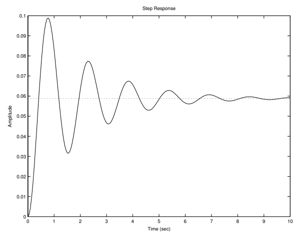


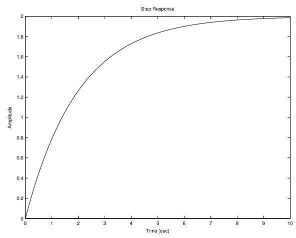


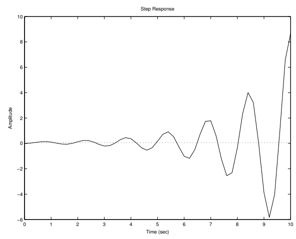

Step Response
Amplitude
Time (sec)

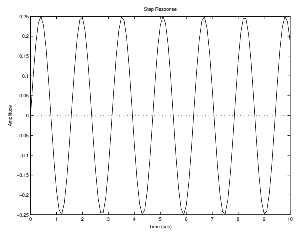

Step Response
Amplitude
Time (sec)

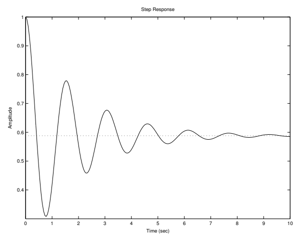

Step Response
Amplitude
Time (sec)

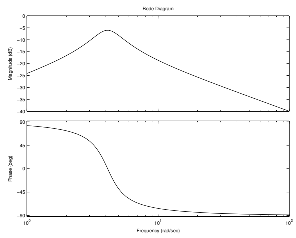

Step Response
Amplitude
Time (sec)

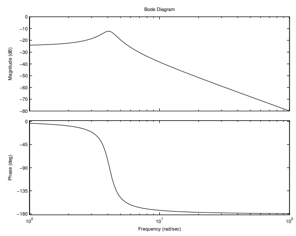

Step Response
Amplitude
Time (sec)

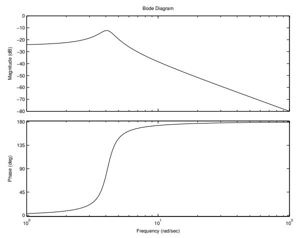

Step Response
Amplitude
Time (sec)

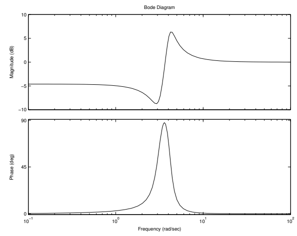

Step Response
Amplitude
Time (sec)

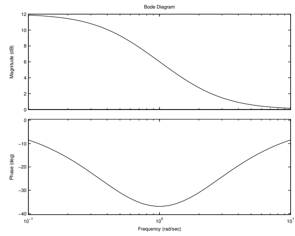

Step Response
Amplitude
Time (sec)

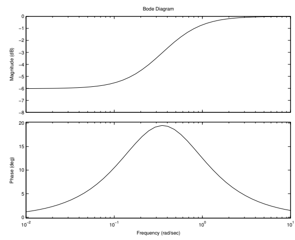

Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/sec)

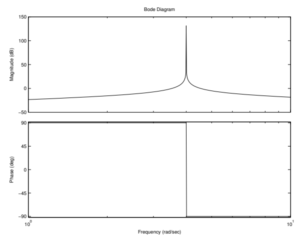

Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/sec)

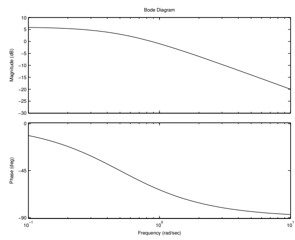

Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/sec)


Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/sec)

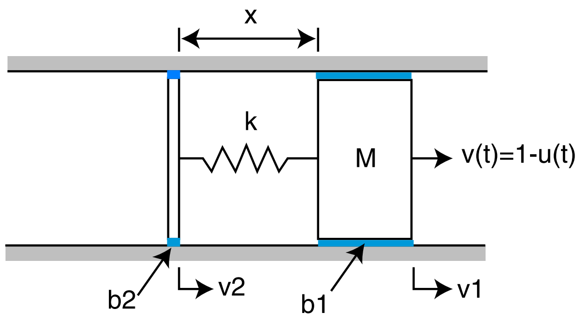

Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/sec)


Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/sec)


Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/sec)

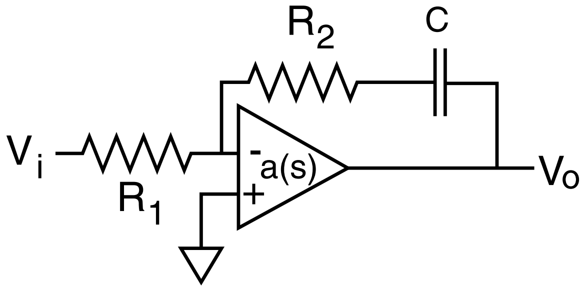

Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/sec)

Problem 2



The figure above shows a system which consist of a mass (M), spring (k), and two dampers (b1, b2). The spring is attached at one end to the mass and to the damper (b2), which is massless at the other. The mass is pulled by a velocity source (v(t)). x denotes the extension of the spring. v_1 is the velocity of the mass and v_2 is the velocity of the second damper. $M = 1$ kg, $b_1 = 1$ Ns/m, $b_2 = 9$ Ns/m, $k = 9$ N/m.
a) find $v_1(0^-)$, $v_2(0^-)$, and $x(0^-)$
b) find $x(0^+)$ and $\dot{x}(0^+)$
c) write the differential equation for the system in terms of x.
d) find $x(t)$ given the initial conditions in c.

Problem 3



a) If $a(s) = 10^6$, find the transfer function of Op-Amp circuit above.
b) If this circuit were used as a controller, what type of controller would it be?
c) If $a(s) = \frac{10^6}{s}$ what is the transfer function of the circuit?
d) $C = 1\,\mu F$, $R_1 = 1e4\,\Omega$, $R_2 = 5e4\,\Omega$. Plot $M(\omega)$ and $\phi(\omega)$