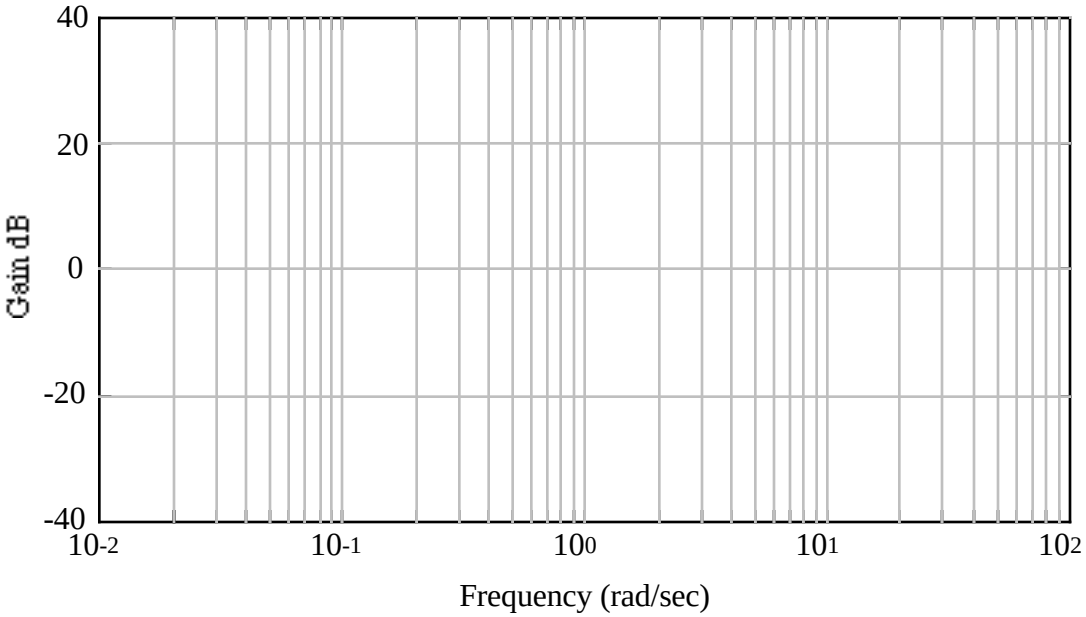
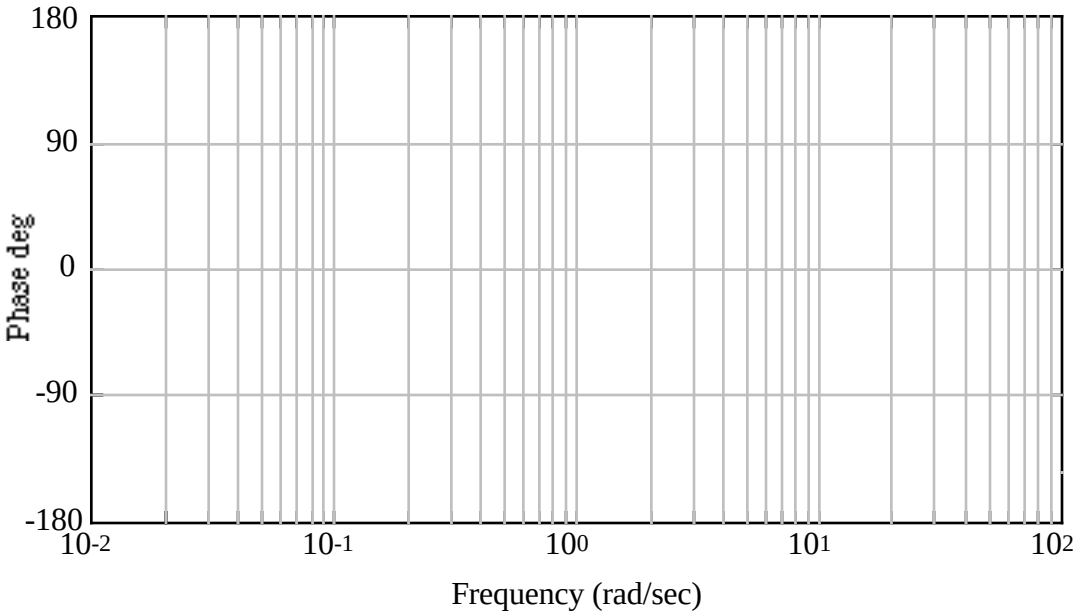
1. For the transfer function,

$$G(s) = \frac{(s+10)}{(s+1)}$$

(10pts) Sketch the Bode Diagram on the graph below first using straight line asymptotes for magnitude and phase, then sketching the "exact " response.





_____/10pt's

(10 pts) 2. The Nyquist diagram is drawn below of open-loop transfer functions, *KG(s)* with $K = 1$. State the gain and phase margins for the systems, whether the system is stable for $K = 1$ (circle Yes or No) and the range of positive stable gains, K for the system (state none if the closed-loop system is always unstable)

for $KG(s) = \dfrac{4K}{s(s+1)(s+3)}$

Gain Margin = _____

Phase Margin = _____

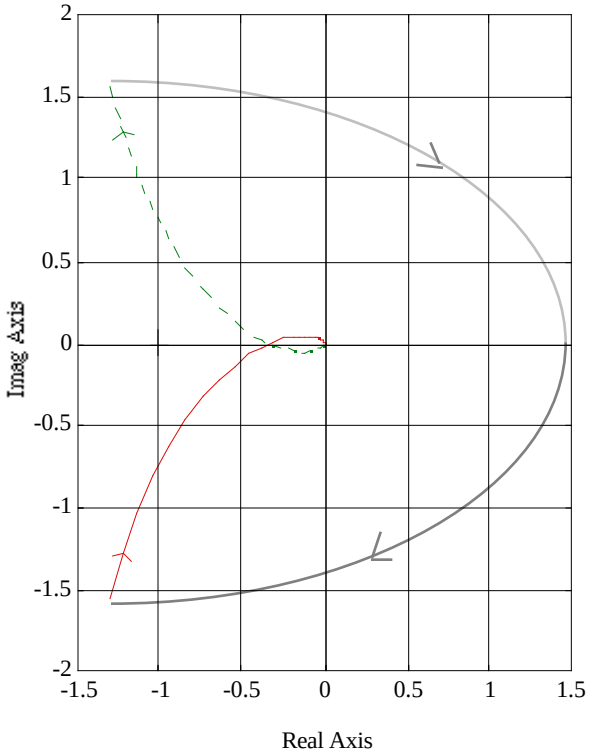
Stable at $K = 1$? YES or NO (circle one)

Maximum Stable Gain,

K_{max} = _____

Minimum Stable Gain,

K_{min} = _____

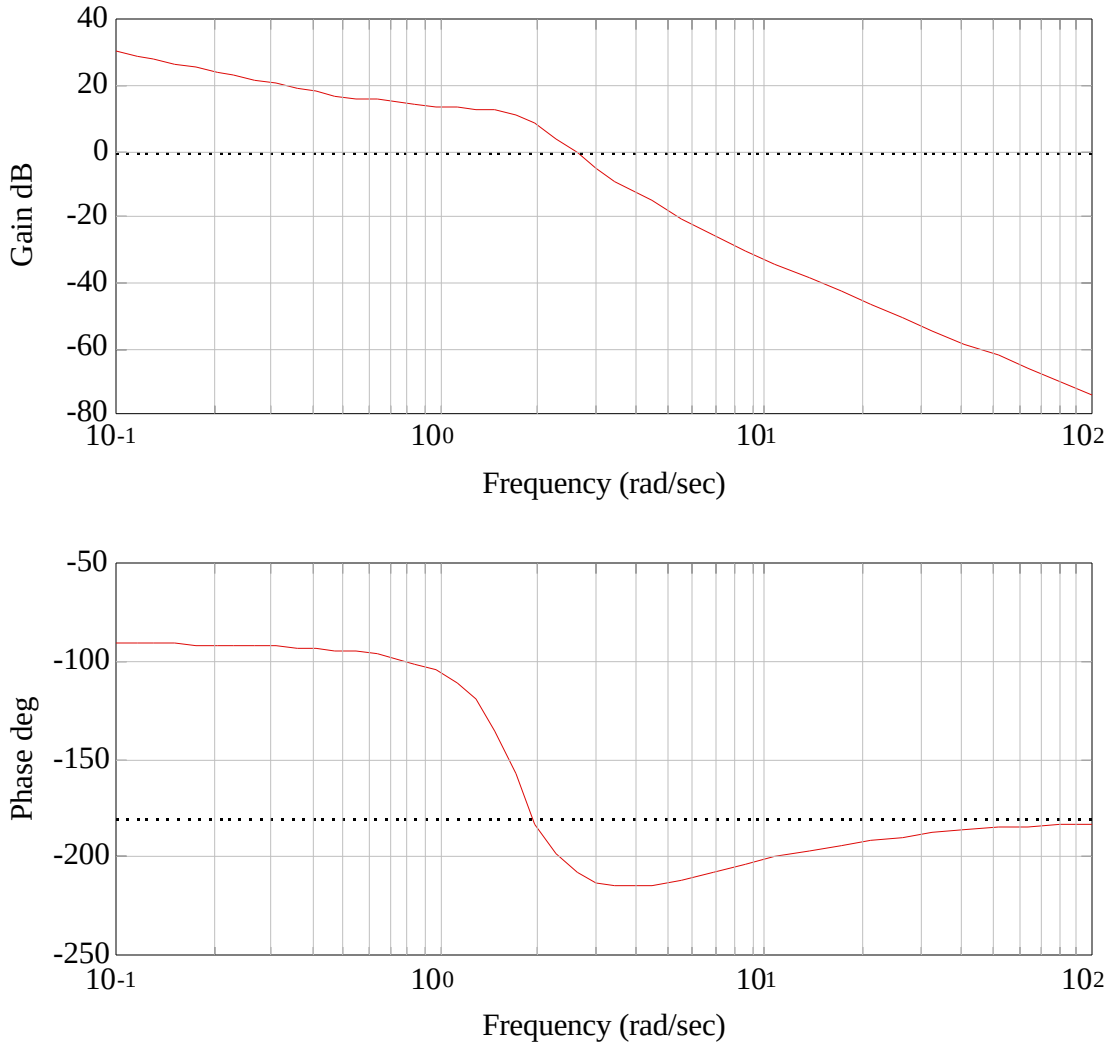


(10 pts) 3. In the lab and in the lecture, the effects of Proportional(P), Integral(I), and Derivative(D) control action were discussed and demonstrated. Under the codes "P", "I" and "D" in the table below, indicate the effect of these control actions on Closed-Loop response by entering "increases", "decreases", or "no effect" in each open box

Effect	**P**	**I**	**D**
Speed of Response			
Steady-State Error			
Stability			

_____/20 pt's

4. An open-loop system transfer function, $KG(s)H(s)$, was measured with $K = 1$, and the Bode Diagram below plotted.



(4 pts) a) Is the system stable at $K = 1$? YES or NO (circle one)

(4 pts) b) What is the maximum stable value of K? K_{max} = _____ dB

(4 pts) c) What is the maximum stable value of K(linear scale)? K_{max} = _____

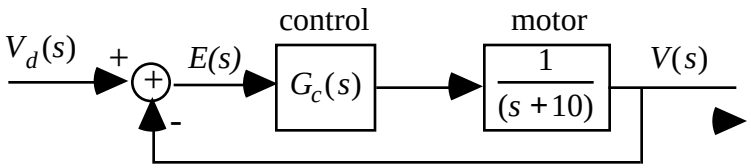
(4 pts) d) What value of K gives a phase margin of 45 degrees? K_{45} = _____ dB

(4 pts) e) Decreasing the gain, K makes the system respond (circle one below)

a) faster b)slower c) has no effect

_____/20 pt's

5. The block diagram below represents an electric motor speed control. The operator sets the desired speed, $V_d(s)$, which is compared to the actual speed of the motor, $V(s)$, in order to develop the error, $E(s)$, which is the input to the control, $G_c(s)$.



(5 pts) a) What is the open-loop system time constant of the motor?

sec.

Open-Loop Motor Time Constant

(5 pts) b) For proportional control, $G_c(s) = K_p = 10$, what is the steady-state error in automobile speed when the desired speed corresponds to a "constant" step of amplitude, $v_d = 5$?

Steady-State Speed Error

(5 pts) c) For proportional control, $G_c(s) = K_p = 10$, what is the closed-loop system time constant?

sec.

System Time Constant

(5 pts) d) For integral control, $G_c(s) = \frac{K_I}{s} = \frac{0.5}{s}$, what is the steady-state error in automobile speed?

Steady-State Speed Error

_____/20 pt's

6. For a system whose response is modeled by the ordinary differential equation below,

$$3\ddot{x}(t) + 2\dot{x}(t) + x(t) = 4u(t)$$

(5 pts) a) Write the transfer function in the box for $X(s) = \mathcal{L}(x(t))$ and $U(s) = \mathcal{L}(u(t))$.

$$\frac{X(s)}{U(s)} =$$

Transfer Function

(5 pts) a) Write the characteristic equation for the system in the box provided.

Characteristic Equation

(5 pts) c) For the state-equations below, write the characteristic equation in the box provided.

$$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 1 & -2 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 1 \\ -2 \end{bmatrix} u(t)$$

Characteristic Equation

_____/15 pt's

7. An automobile has the non-linear differential equation for speed, $v(t)$ (m/sec) versus input to the engine actuator, $e(t)$ (volts) shown below.

$$\dot{v} = -v^2 + 20e$$

(4 pts) a) Find the equilibrium value(s) of $e(t) = e_{equil}$ corresponding to an operating speed of $v(t) = 10$ m/sec and enter it in the box below.

u_{equil} = volts

(4 pts) b) Define a new set of variables about which a linear approximation for the above equation can be derived.

(7 pts) c) Find the linearized ordinary differential equation(s) in state space form about the equilibrium point found in part a) and enter your result in the box below

Linearized State Equation(s)

_____/15 pt's