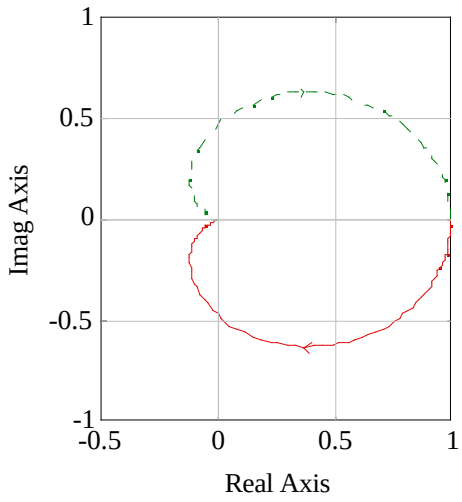
1. The Nyquist diagram is drawn below of open-loop transfer functions, *KG(s)* with $K = 1$. State the gain and phase margins for the systems, whether the system is stable for $K = 1$ (circle Yes or No) and the range of positive stable gains, $K$ for the system (state none if the closed-loop system is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

8 pts) a) Gain Margin = _____ Phase Margin = _____

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

Approximate Stable range for K _____

$$KG(s) = \frac{K}{2s^2 + 3s + 1}$$

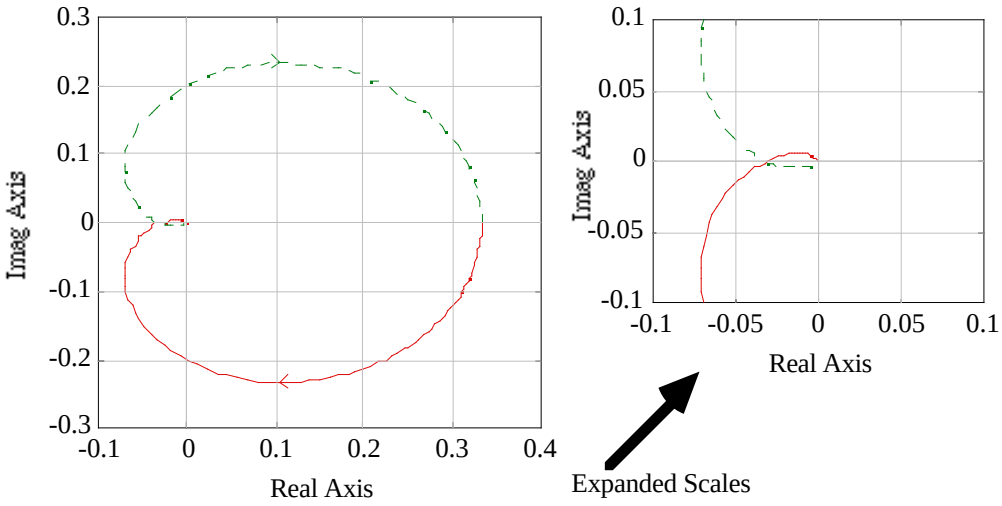



8 pts) b) Gain Margin = _____ Phase Margin = _____

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

Approximate Stable range for K _____

$$KG(s) = \frac{K}{(s+3)(s+1)^2}$$

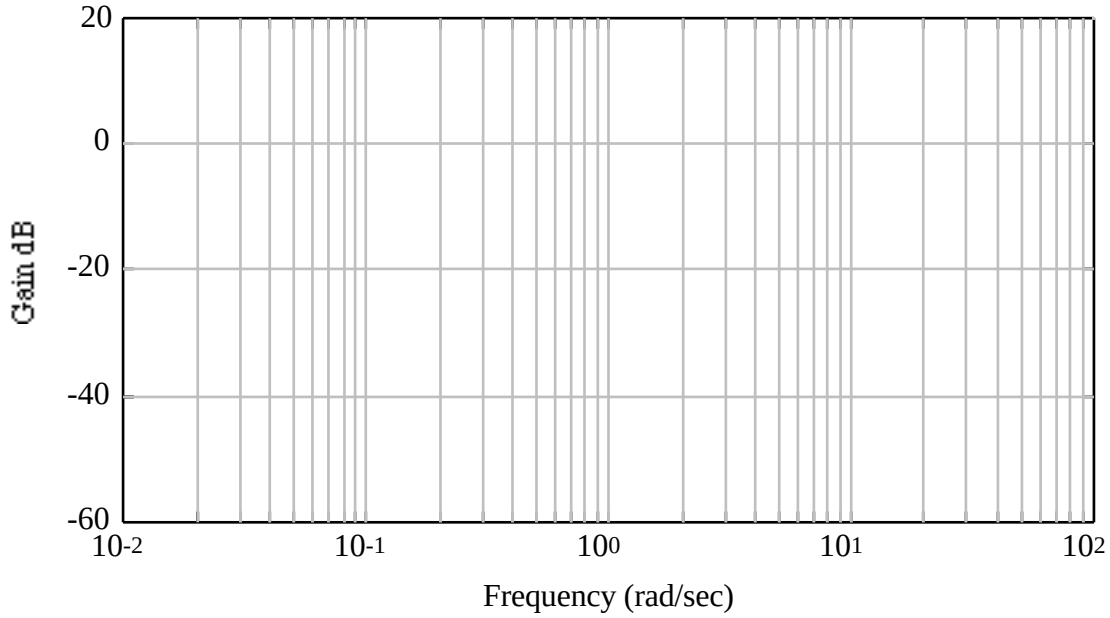


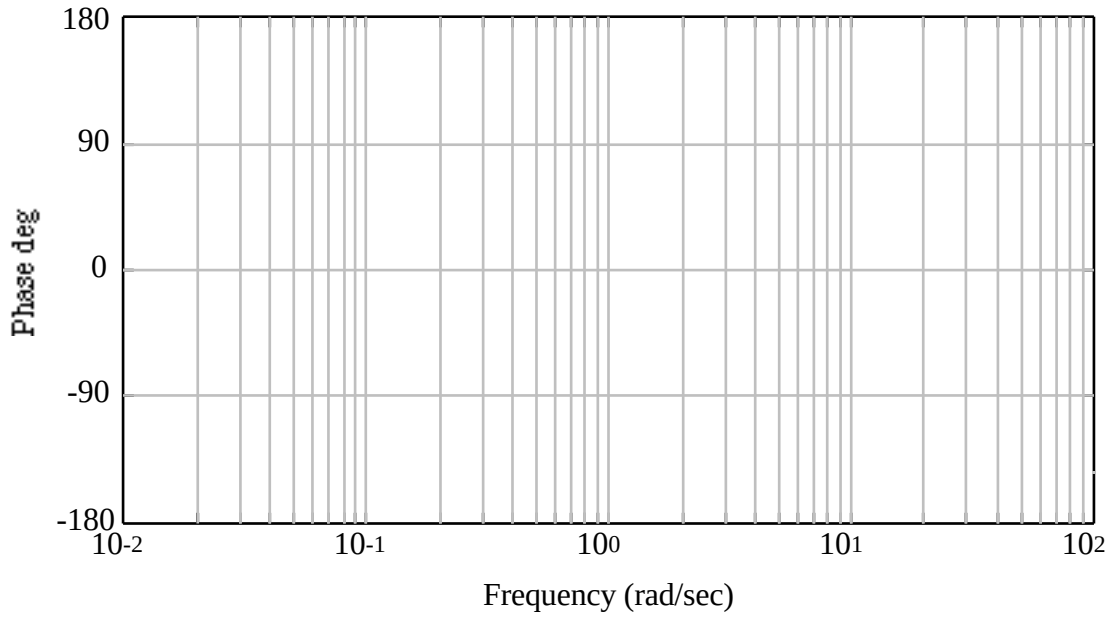

_____/16pt's

2. For the transfer function,

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

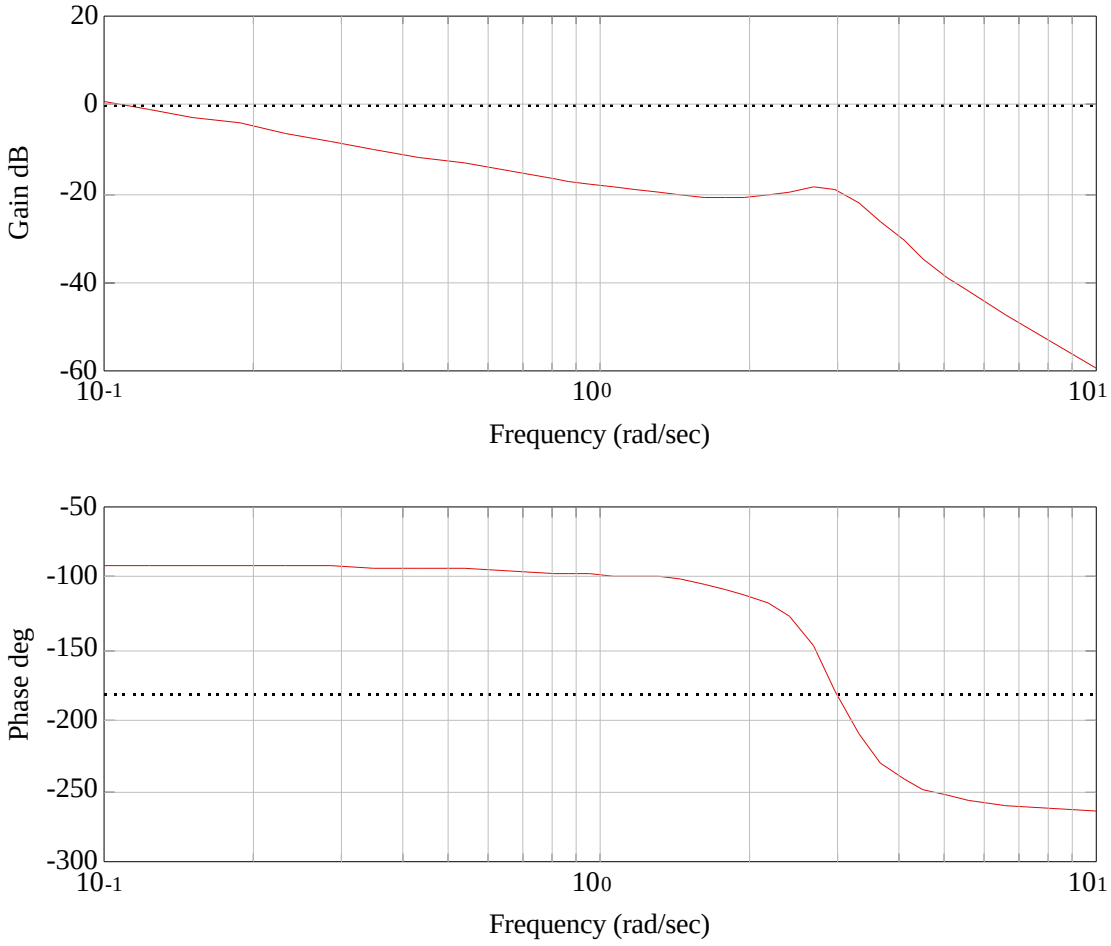
(14pts) Sketch the Bode Diagram on the graph below first using straight line asymptotes for magnitude and phase, then sketching the "exact " response.




_____/14 pt's

3. For an open-loop system transfer function, $KG(s) = \dfrac{K}{s(s^2 + s + 9)}$, with $K = 1$, the Bode Diagram below was plotted.




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

(4 pts) b) What is the Gain Margin? GM = _____ dB

(4 pts) c) What is the Phase Margin? PM = _____ deg

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

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

_____/20 pt's

(5 pts) 4. a) For the ordinary differential equation below, write the corresponding transfer function in the box provided for $X(s) = \mathcal{L}(x(t))$ and $U(s) = \mathcal{L}(u(t))$.

$$3\ddot{x}(t) + \dot{x}(t) + 4x(t) = 5u(t)$$

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

Transfer Function

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

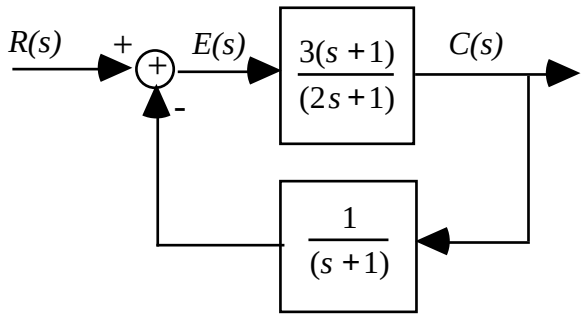
$$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 1 & -2 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u(t)$$

Characteristic Equation

(5 pts) c) For the block diagram below, what is the error transfer function $C(s)/R(s)$. Simplify your result as much as possible - no partial credit!

$$\frac{C(s)}{R(s)} =$$

Transfer Function




_____/15 pt's

5. An electric automobile has thedifferential equation for speed, $v(t)$ (m/sec) versus input electric potential, $e(t)$ (volts) shown below.

$$\dot{v} = -4v^2 + 10e$$

(4 pts) a) Find the equilibrium value(s) of $e(t) = e_{equil}$ corresponding to an operating speed of $v(t) = 20$ rad/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.

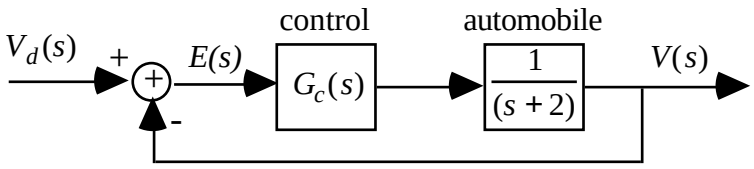
(7 pts) c) Find the linearized ordinary differential equation(s) in state space form about the equilibrium point found in part a) and enter your result in the box below

| |
|---|

Linearized State Equation(s)

_____/15 pt's

(20 pt's) 6. The block diagram below represents an automobile speed control. The driver sets the desired speed, $V_d(s)$, which is compared to the actual speed of the automobile, $V(s)$, in order to develop the error, $E(s)$, which is the input to the control, $G_c(s)$.




(5 pts) a) For proportional control, $G_c(s) = K_p$, what is the steady-state error in automobile speed?

Steady-State Speed Error

(5 pts) b) For proportional control, $G_c(s) = K_p$, what is the system time constant?

System Time Constant

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

Steady-State Speed Error

(5 pts) a) For integral control, $G_c(s) = \frac{K_I}{s}$, what value of $K_I$ yields critically damped response with two closed-loop poles at $s$ = -1?

$K_I$ =

_____/20 pt's