(5 pts) 1. a) For the differential equation below, write the corresponding transfer function in the box below.

$$5\ddot{y} + 3\dot{y} + 10y = 2f(t)$$

$\frac{Y(s)}{F(s)} =$

Transfer Function

(5 pts) b) For the transfer function below, write the corresponding ordinary differential equation <u>in the box</u> provided.

$$\frac{X(s)}{U(s)} = \frac{4}{s^2 + 3s + 16}$$

Differential Equation

_____/10 pt's

(5 pts) 1. c) For the state-equations below, write the transfer function $Y(s)/U(s)$ in the box provided.

Simplify your result as much as possible and put it in the box provided.

$$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -2 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u(t)$$

$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + [0] u(t)$$

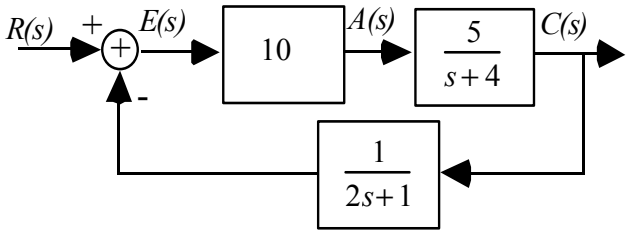
$$\frac{Y(s)}{U(s)} =$$

Transfer Function

(5 pts) d) For the block diagram below, what is the system transfer function $C(s)/R(s)$. Simplify as much as possible and express the result as the ratio of two polynomials.

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

Transfer Function



_____/10 pt's

2. A steel plant designer finds the following non-linear differential equation model for steel billet velocity v (ft/sec) versus electric motor drive e (volts)

$$\dot{v} + 10v + v^2 = 5ve$$

(5 pts) a) Find the equilibrium input throttle position $e = e_o$ corresponding to an billet operating speed of 5 ft/sec and enter it in the box below.

$e_0 =$	volts

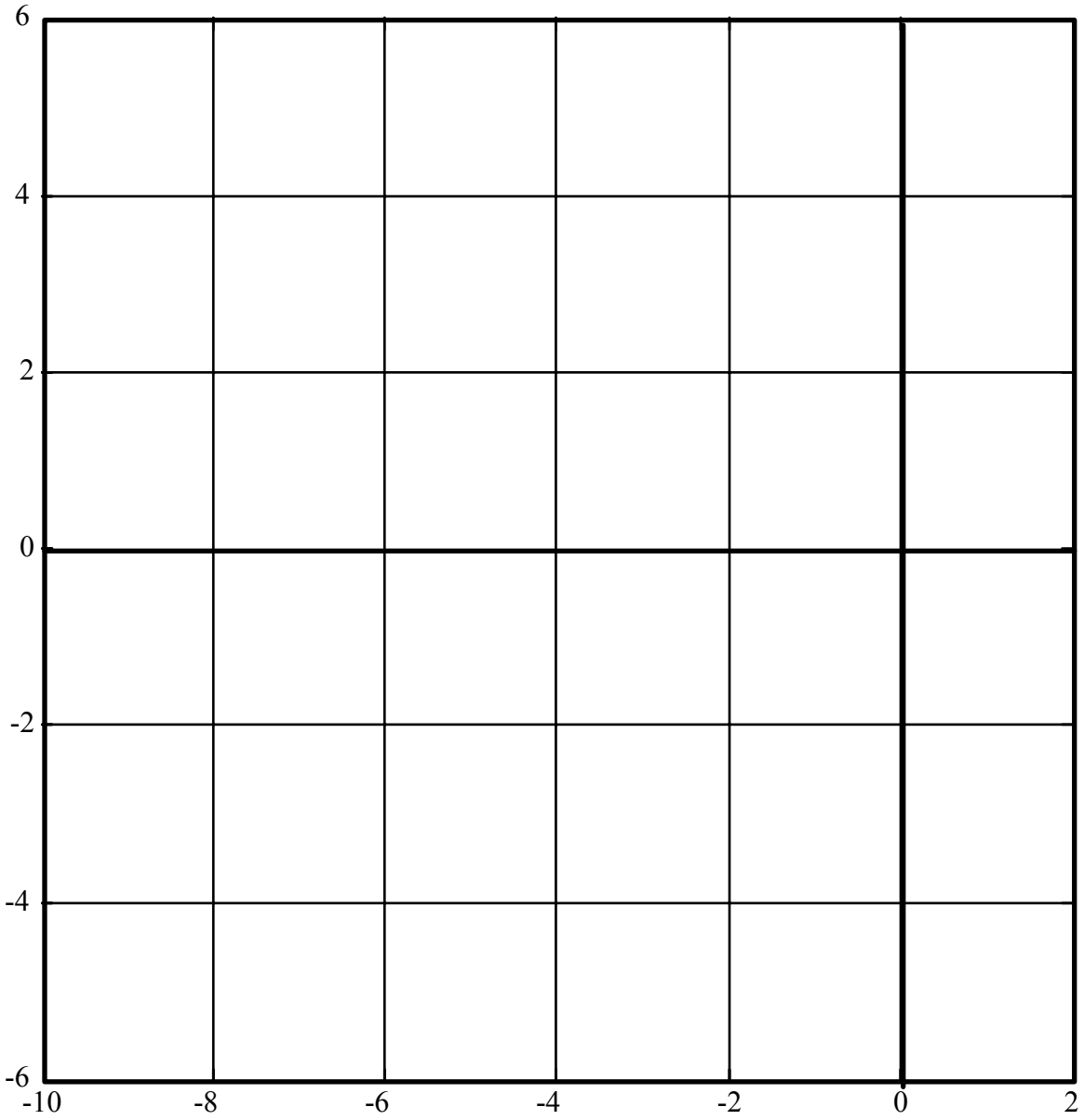
(5 pts) b) Define a new set of variables about which a linear approximation for the above equation can be derived.

(10 pts) c)Find the linearized ordinary differential equation about the equilibrium point found in part a) and enter your result in the box below

Linearized Differential Equation(s)

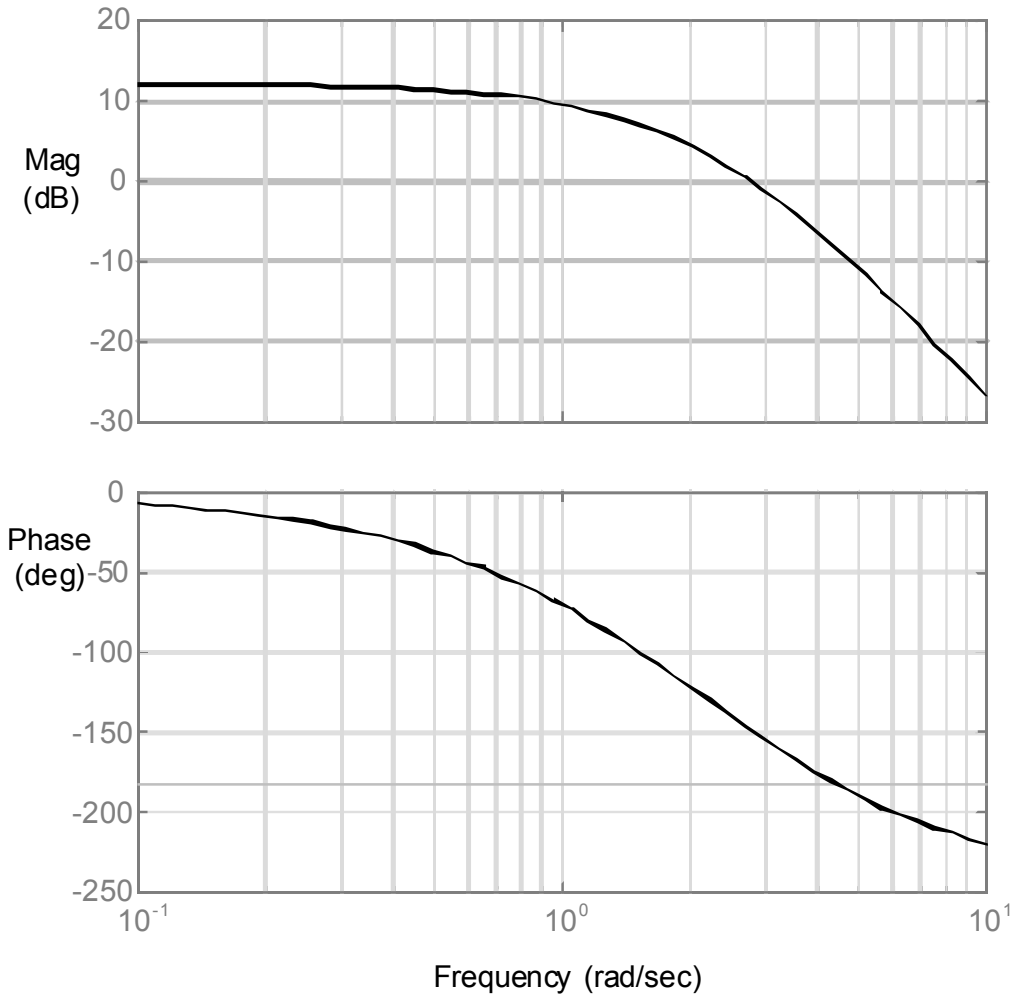
_____/20 pt's

(15 pts) 3.For an open-loop system transfer function, $kG(s)H(s) = \dfrac{ks}{(s+4)\left((s+2)^2+2^2\right)}$, plot the root locus diagram on the axes below for $0 < k < \infty$. When they exist, how features such as asymptotes, breakaway points, angles of departure, instability frequencies, etc.



_____/15 pt's

4. The open-loop system transfer function of an hydraulic actuator, *KG(s)* was measured for $K = 1$, at Radcliffe Engineering and the Bode Diagram below plotted.



(5 pts) a) Is the closed-loop system stable at K = 1? YES or NO (circle one)

(5 pts) b) What is the closed-loop system's Gain Margin? GM = _____ dB

(5 pts) c) What is the closed-loop system's Phase Margin? PM = _____ deg

(5pts) d) What is the maximum closed-loop stable value of K? K_{max} = _____ dB

(5 pts) e) What value of K gives a phase margin of 60 degrees? K_{45} = _____ dB

(5 pts) f) For $K = 1$, what is the closed-loop system's steady-state error for a unit step input? e(∞) = _____

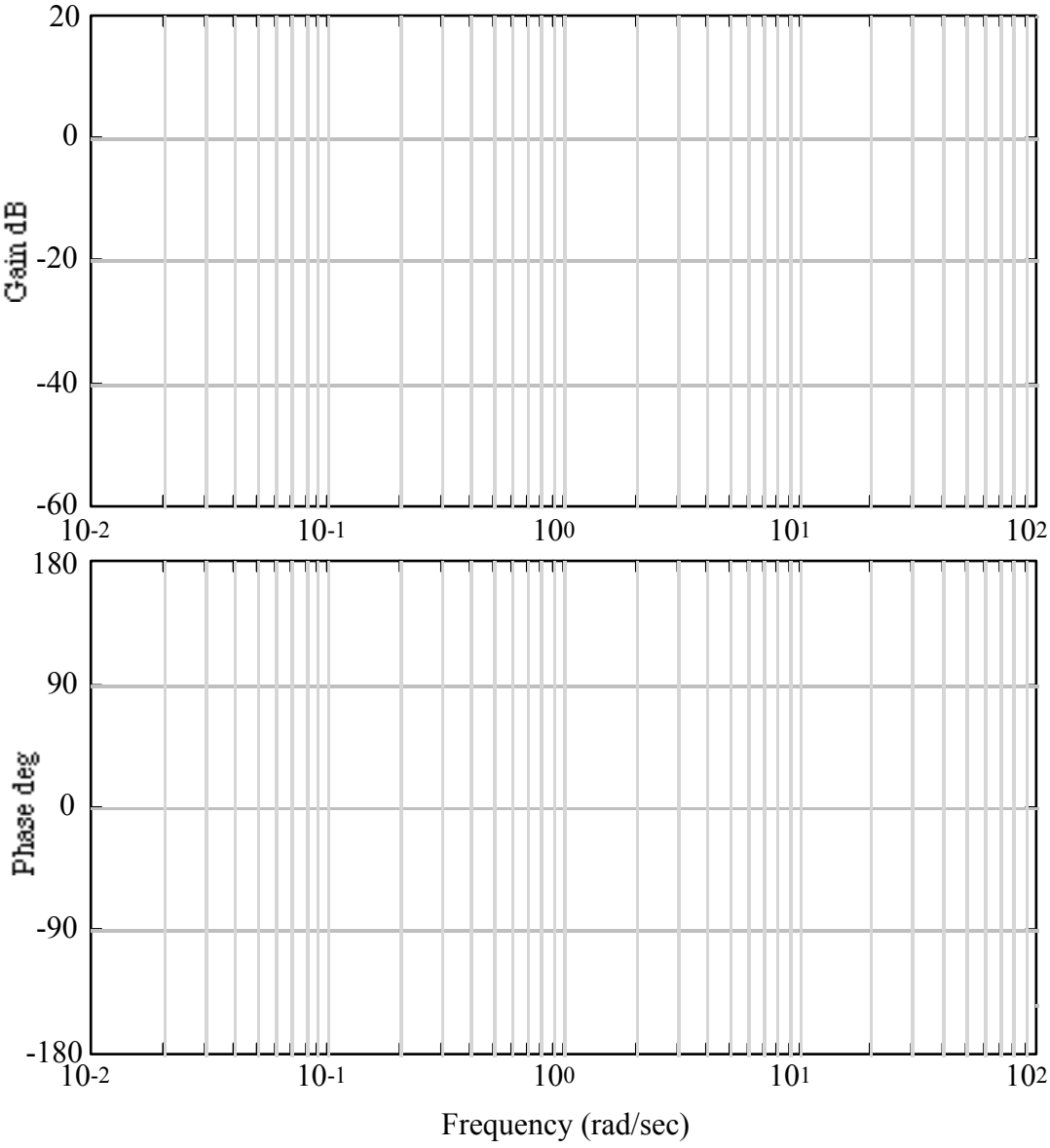
(5 pts) g) For $K = 1$, what is the maximum stable time delay that can be added to the closed-loop system.(Hint: This time delay will make the Phase Margin to go to zero) τ = _____(sec)

_____/35 pt's

5. For the transfer function,

$$G(s) = \frac{20}{(s+1)(s+10)}$$

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



_____/10 pt's