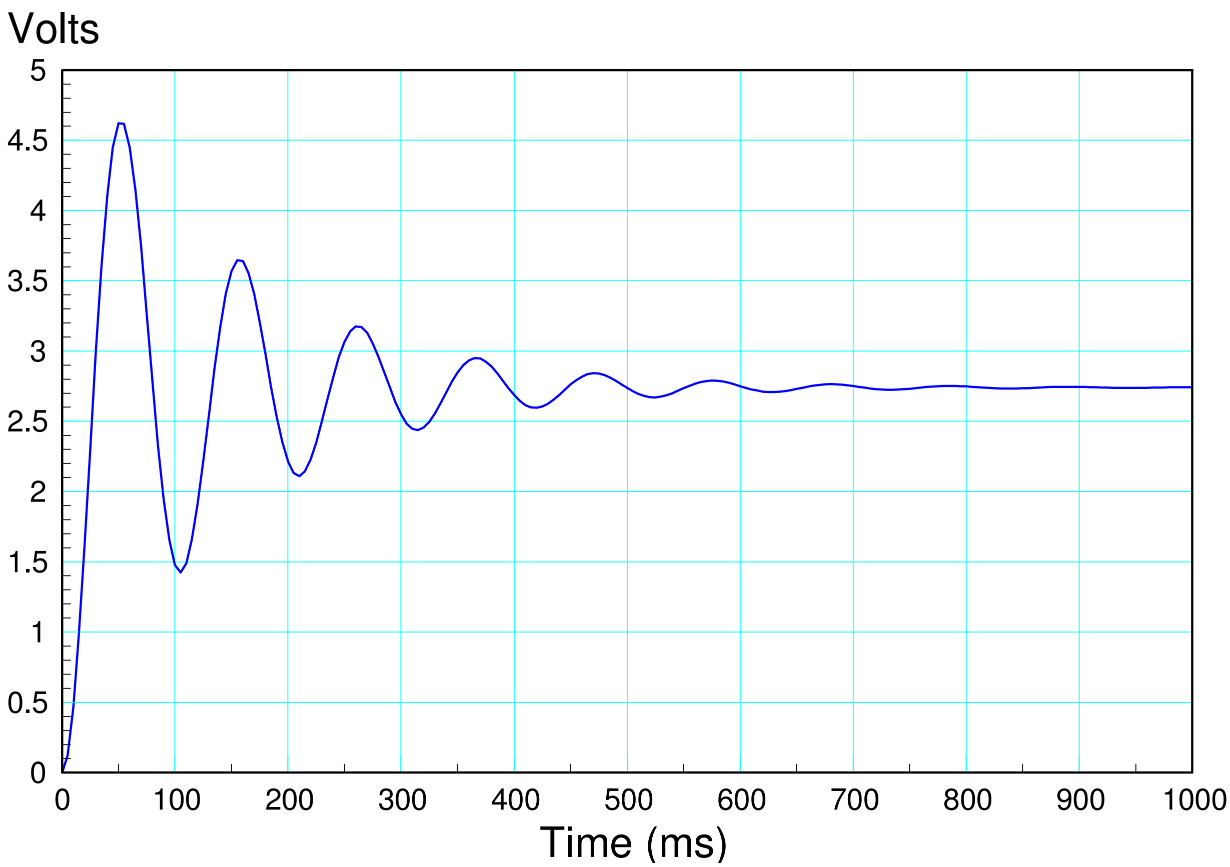
ECE 461/661 - Test #2: Name ____________________

Feedback and Root Locus - Fall 2020

1) Determine the system with the following step response



DC gain = 2.75

Ts = 700ms

$$\sigma = \frac{4}{700ms} = 5.71$$

$$\omega = \left(\frac{5 \text{ cycles}}{520\text{ms}}\right) 2\pi = 60.4$$

$$G(s) \approx \left(\frac{10,122}{(s+5.71+j60.4)(s+5.71-j60.4)}\right)$$

2) The root locus of G(s) is shown below.

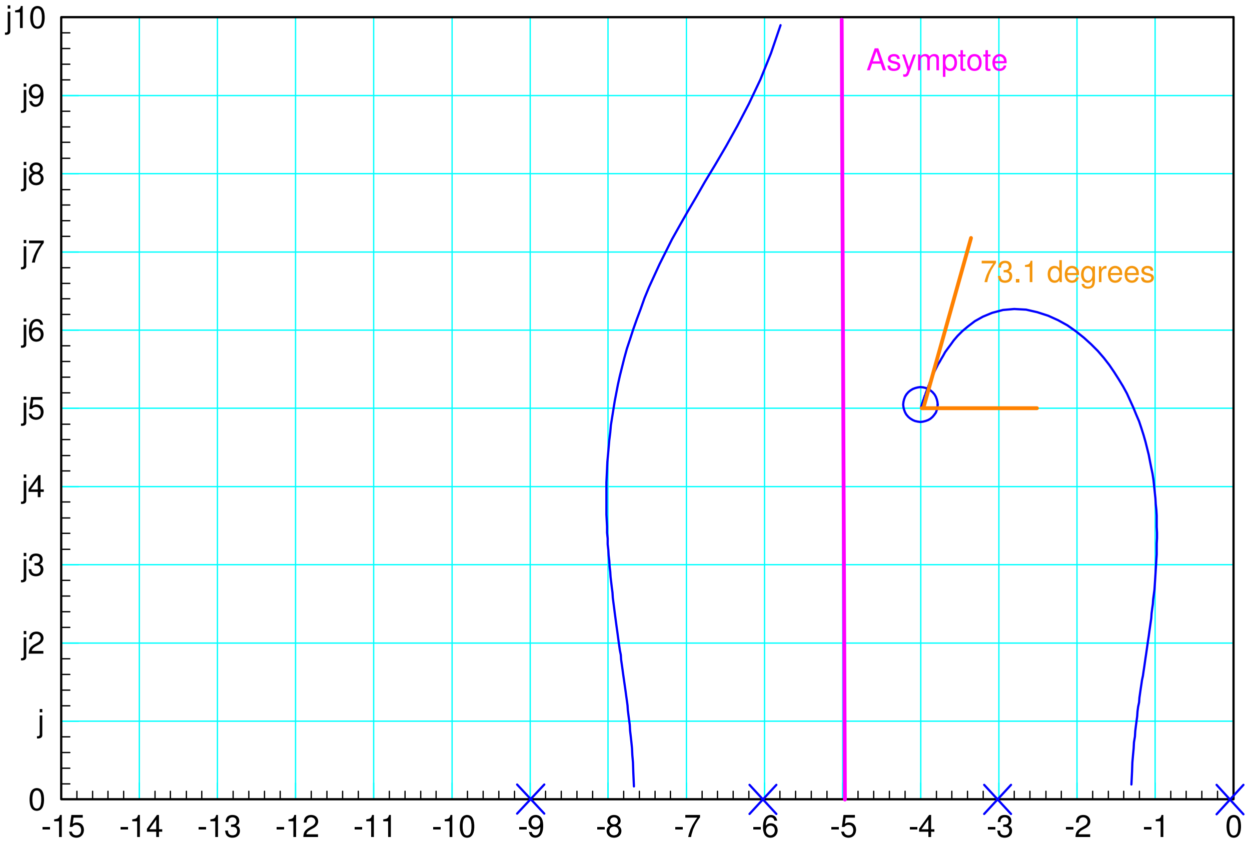
$$G(s) = \left(\frac{100(s+4+j5)(s+4-j5)}{s(s+3)(s+6)(s+9)}\right)$$

Determine the following

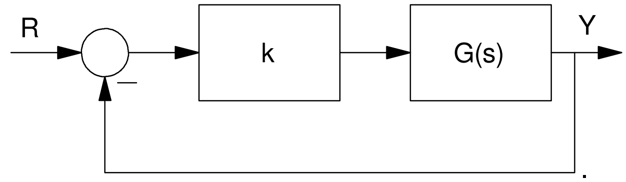
- Approach angle to the zero at -4 + j5 — **73.618 deg**
- The breakaway point (approx) — **-1.305, -7.671**
- The gain, k, at the breakaway point, and — **0.025 , 0.021**
- The asymptotes (number, angle, intercept) — **2 asymptotes**

+/- 90 degrees

intercept s = -5



3) Design a gain compensator (K(s) = k) so that the feedback system has 10% overshoot for a step input.



Also determine

- The resulting error constant, Kp,
- The closed-loop dominant pole, and
- The step response of the closed-loop system (Matlab plot OK for this)

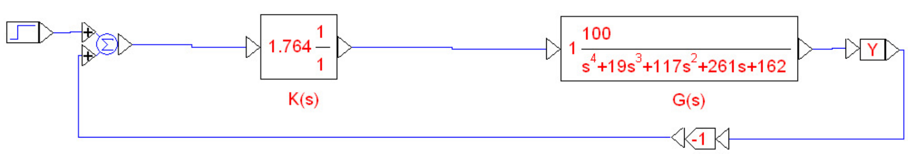
Assume

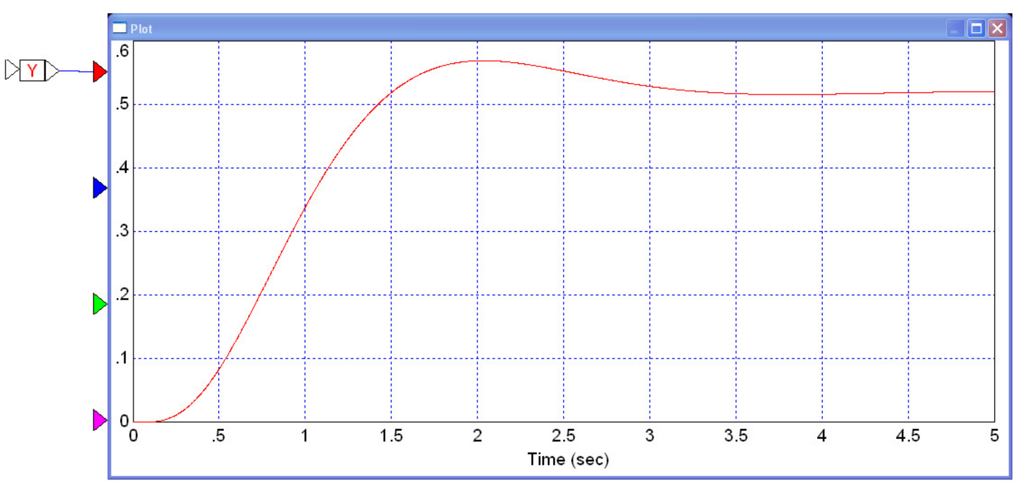
$$G(s) = \left(\frac{100}{(s+1)(s+3)(s+6)(s+9)}\right)$$

For 10% overshoot,

- the damping ratio is 0.591
- The angle of s = 53.781 degrees

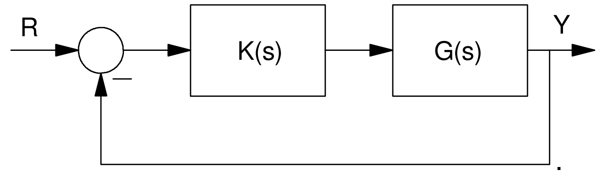
zeta =	**0.591**
s =	**-1.305 + j1.782**
k =	**1.764**
Kp =	**1.089**





4) Design a compensator, K(s), so that the closed-loop system has

- No error for a step input
- A 2% settling time of 3 seconds
- 10% overshoot for a step input.



$$G(s) = \left(\frac{100}{(s+1)(s+3)(s+6)(s+9)}\right)$$

Plot the step response of the resulting closed-loop system

$$s = -1.333 + j1.820$$

$$K(s) = k\left(\frac{(s+1)(s+3)}{s(s+a)}\right)$$

$$GK = \left(\frac{100k}{s(s+a)(s+6)(s+9)}\right)$$

evaluating what we know

$$\left(\frac{100}{s(s+6)(s+9)}\right)_{s=-1.333+j1.820} = 1.123\angle -160.878^0$$

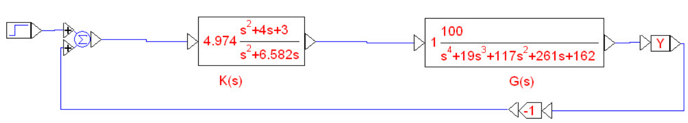
$$\angle(s+a) = 19.122^0$$

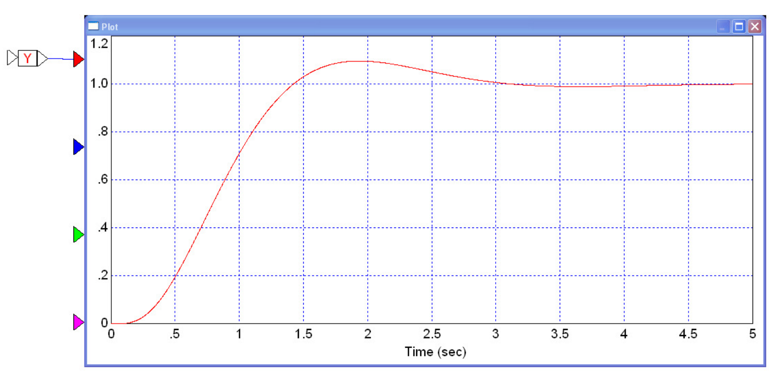
$$a = \frac{1.820}{\tan\left(19.122^0\right)} + 1.333 = 6.582$$

$$\left(\frac{100}{s(s+6.582)(s+6)(s+9)}\right)_{s=-1.333+j1.820} = 0.202\angle 180^0$$

$$k = \frac{1}{0.202} = 4.974$$

$$K(s) = 4.974\left(\frac{(s+1)(s+3)}{s(s+6.582)}\right)$$





5) Design a circuit to implement K(s)

$$K(s) = \left(\frac{200(s+3)(s+5)}{s(s+14)}\right)$$

Rewrite as

$$K(s) = \left(\frac{20(s+5)}{(s+14)}\right)\left(\frac{10(s+3)}{s}\right)$$

There are many answers - this is one solution