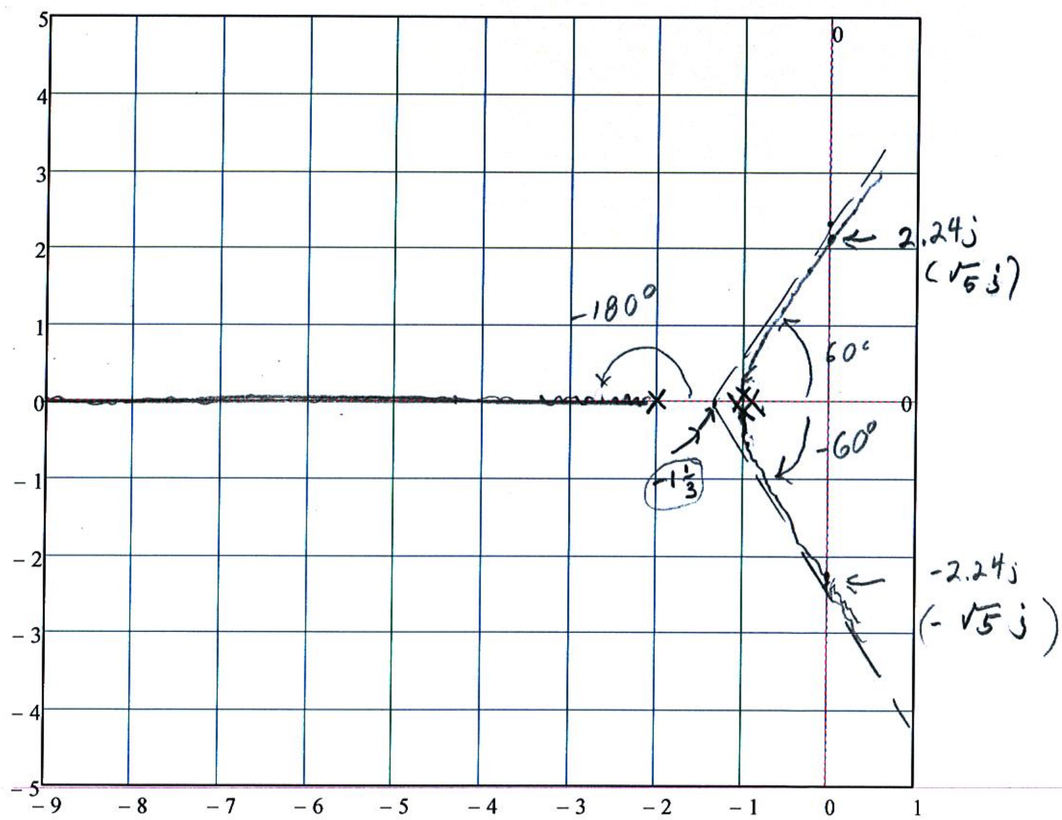
Name *Solution*

Problem 1: (33%)

On the grid provided sketch the root locus of the transfer function:

$$L(s) = \frac{K}{(s^2+2s+1)(s+2)},$$

where L(s) is the loop transfer function.



Answer the following (to aid with your sketch and for partial credit if needed.)

If certain questions do not apply to this root locus sketch just put NA (not applicable)

1). Finite open loop poles (number and locations)

3 poles at $s=-1$, $s=-1$, $s=-2$

2). Finite open loop zeros (number and locations)

No zeros

Name *Solution*

Problem 1: (cont')

3). Number of branches

$N_p - N_z = 3 - 0 = 3$

4). Asymptote intersection with real axis

$$\frac{-1 -1 -2}{3} = -\frac{4}{3}$$

5). Asymptote angles in the complex plane

$-180°, \quad 60°, \quad -60°$

6). Real axis Break-in or Break-out locations

Break-out at -1

7). Angles of departure or arrival from complex poles or zeros

NA

8). Imaginary axis crossings (value of ω, and K)

$s^3 + 4s^2 + 5s + K+2 = 0$

$(-\omega^3 + 5\omega)j + (2 + K - 4\omega^2) = 0$

$\omega(5 - \omega^2) = 0 \qquad \omega = \sqrt{5}$

$K - 18 = 0 \qquad K = 18$

or

s^3	1	5	0
s^2	4	$K+2$	0
s^1	$\frac{K+2-20}{-4}$	0	
s^0	K		

$4\omega^2 + K + 2 = 0$

$4\omega^2 + 20 = 0$

$\omega^2 = -5$

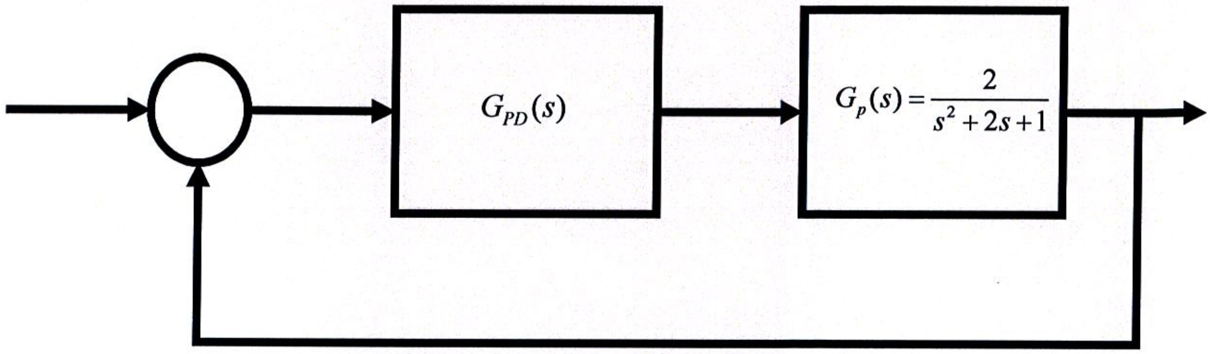
$\omega = j\sqrt{5}$

$K - 18 = 0 \qquad K = 18$

Name Solution

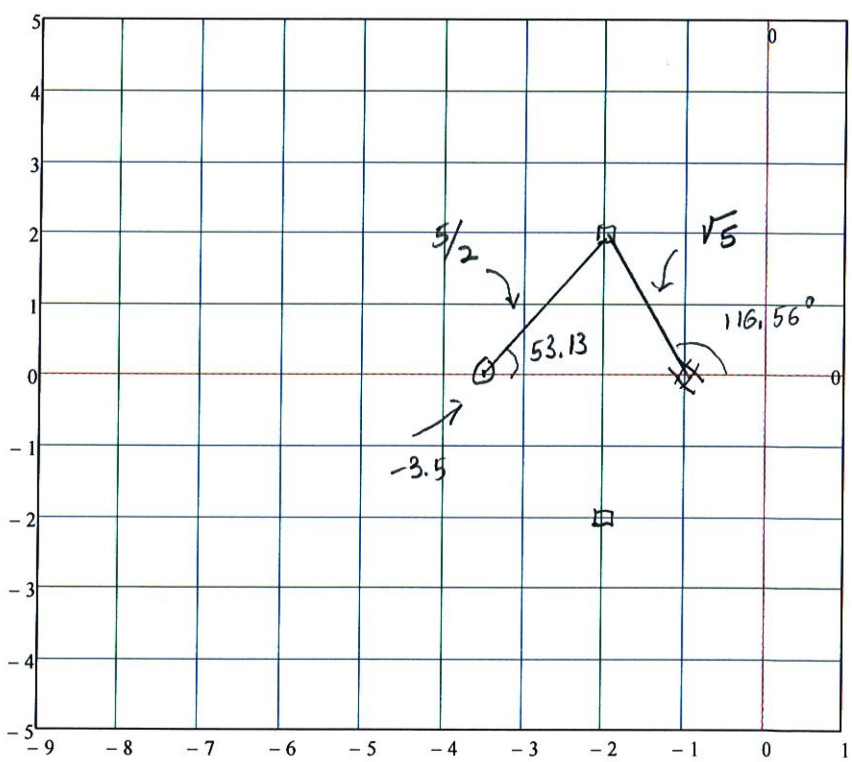
Problem 2:(33%)

For the control system shown in the figure below,



Design a PD (proportional derivative) controller to place the closed loop poles at $s = -2 \pm 2j$ (Calculate K and zero location.) Use the following sketch area to help you visualize your design.

Mark the open-loop poles and zeros, the desired closed-loop pole locations, plot and label line segments from the open loop poles and zeros to the operating points (label angles and line segment lengths)



Name $Solution$

Problem 2:(cont')

(a) Apply the angle criterion:

$\phi_d - 2 \times 116.56° = -180°$

$\phi_d = 53.13°$

$\tan 53.13 = \dfrac{2}{x-2}$

$x = 3.5$

zero at $s = -3.5$

(b) Apply the magnitude criterion:

$K2 = \dfrac{\sqrt{5} \cdot \sqrt{5}}{5/2} = 2$

$K = 1$

(c) Write the control equation.

$G_c(s) = 1 \cdot (s + 3.5) = (s+3.5)$

Name <u>Solution</u>

Problem 3:(34%)

The truth table for a "half adder" is given in the following table

Half Adder Truth Table			
A	**B**	**S**	**C**
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Where A is one binary input, B is the second binary input, S is the sum, and C is the carry bit.

(a) Write the Boolean expression for the "Sum Bit" by applying the so-called Sum-of-Product to the sum (S).

$$(\bar{A} \cdot B) + (A \cdot \bar{B}) = S$$

(b) Write the Boolean expression for the "Sum Bit" by applying the so-called Product-of-Sum to the sum (S).

$$(\bar{A} + \bar{B}) \cdot (A + B) = S$$

(c) Write the Boolean expression for the "Carry Bit" by applying the so-called Sum-of Product to the carry (C).

$$A \cdot B = C$$

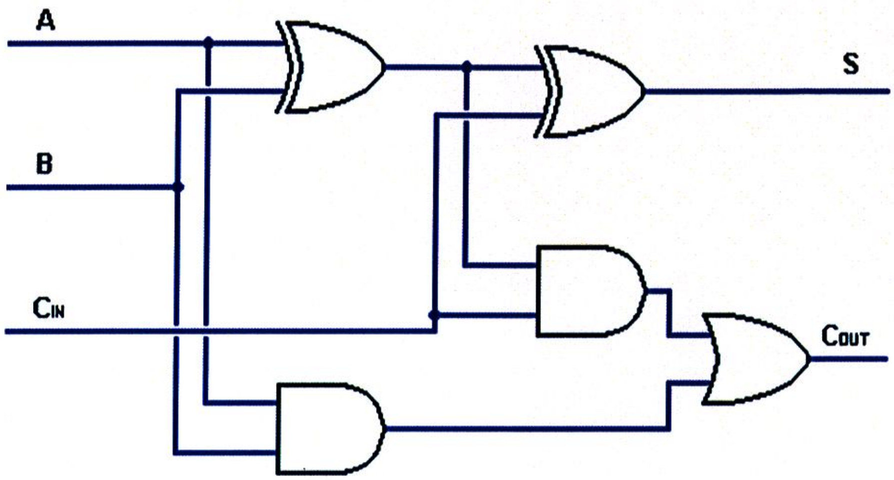
(d) Write the Boolean expression for the "Carry Bit" by applying the so-called Product-of-Sum to the carry (C).

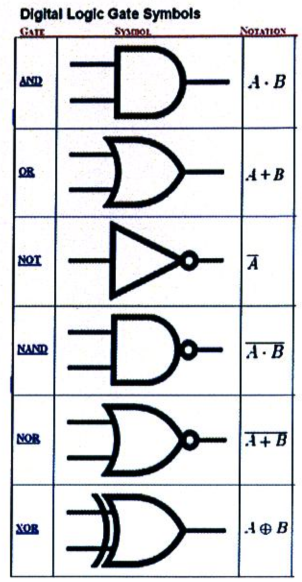
$$(A + B) \cdot (A + \bar{B}) \cdot (\bar{A} + B) = C$$

Name *Solution*

Problem 3: (cont')

Given the following digital circuit generate the truth table relating inputs A, B, and C_{in} to the outputs S and C_{out}.





(e) Fill in the following table:

Truth Table				
C_{in}	A	B	S	C_{out}
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

(f) Write the Boolean expressions for S and C_{out} in terms of the inputs A, B, and C_{in}.

$$(A \oplus B) \oplus C = S$$

$$(A \oplus B) \cdot C_{in} + A \cdot B = C_{out}$$