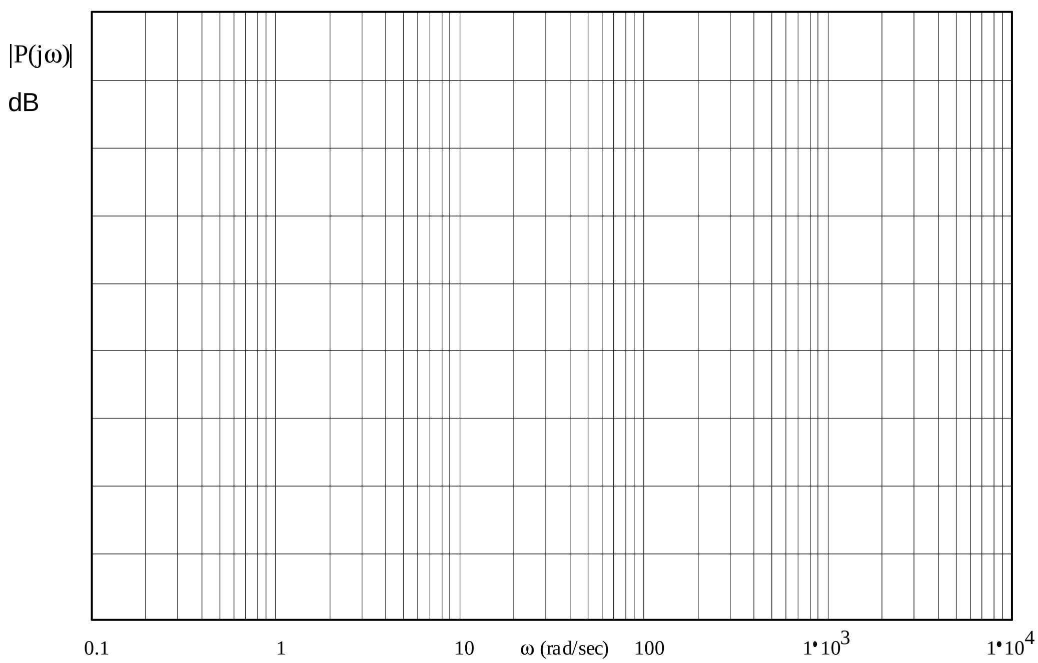
ECE 3510 Exam 3 given: Spring 09

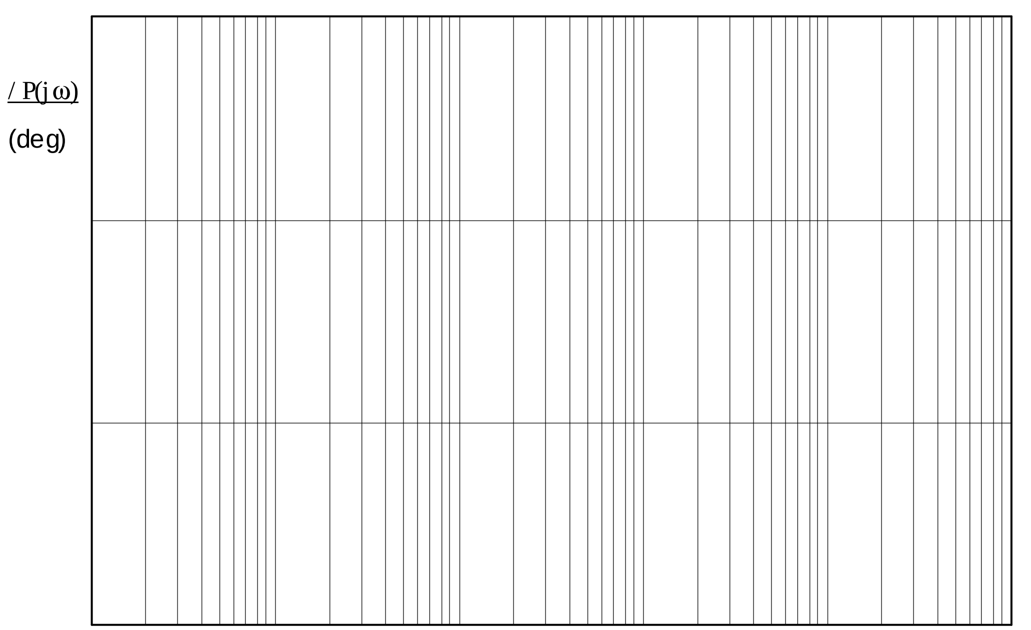
(The space between problems has been removed.)

Open-book part (Sp09 Exam 3 had no closed book part.)

1. (14 pts) Sketch the Bode plots for the following transfer function. Make sure to label the graphs as necessary to show the magnitudes and slopes. Please use a straight edge. Also draw the "smooth" lines.

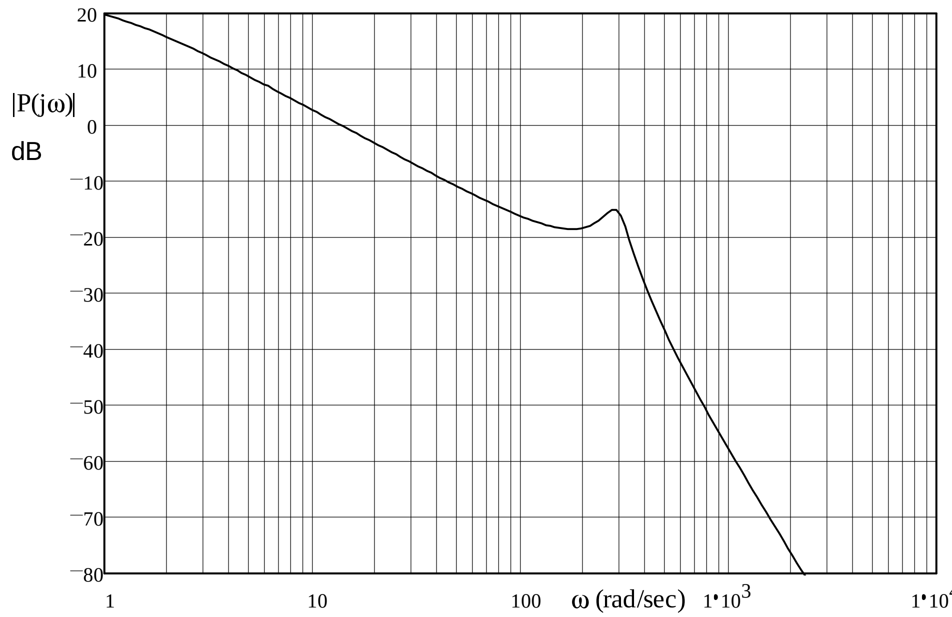
$$P_{b.}(s) = \frac{\left(s^2 + 4\cdot s + 400\right)}{s\cdot(s+6)}$$

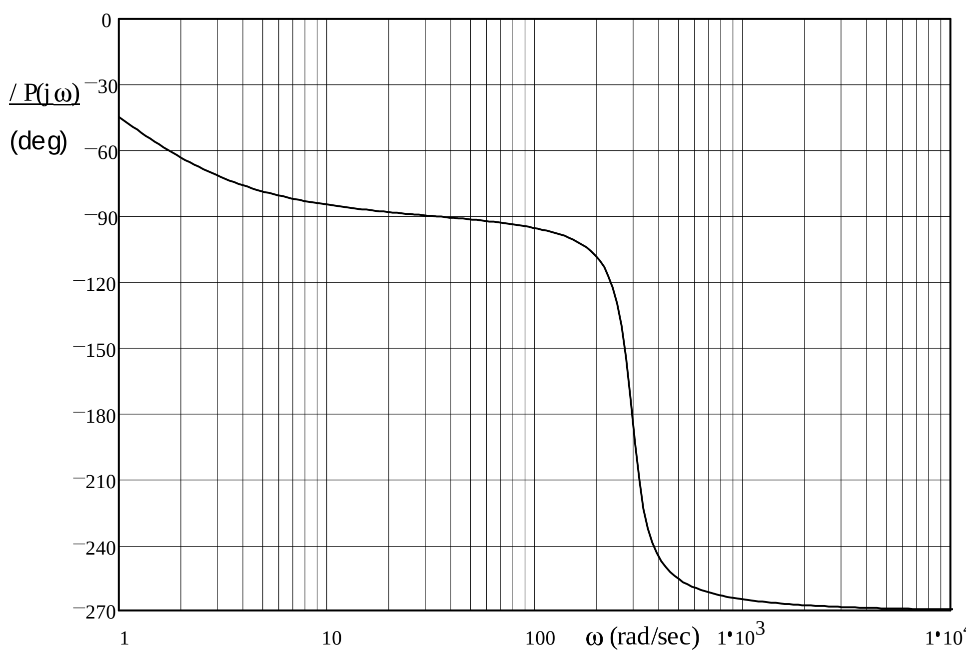




2. (10 pts) The open-loop Bode plots of a system are given at right.

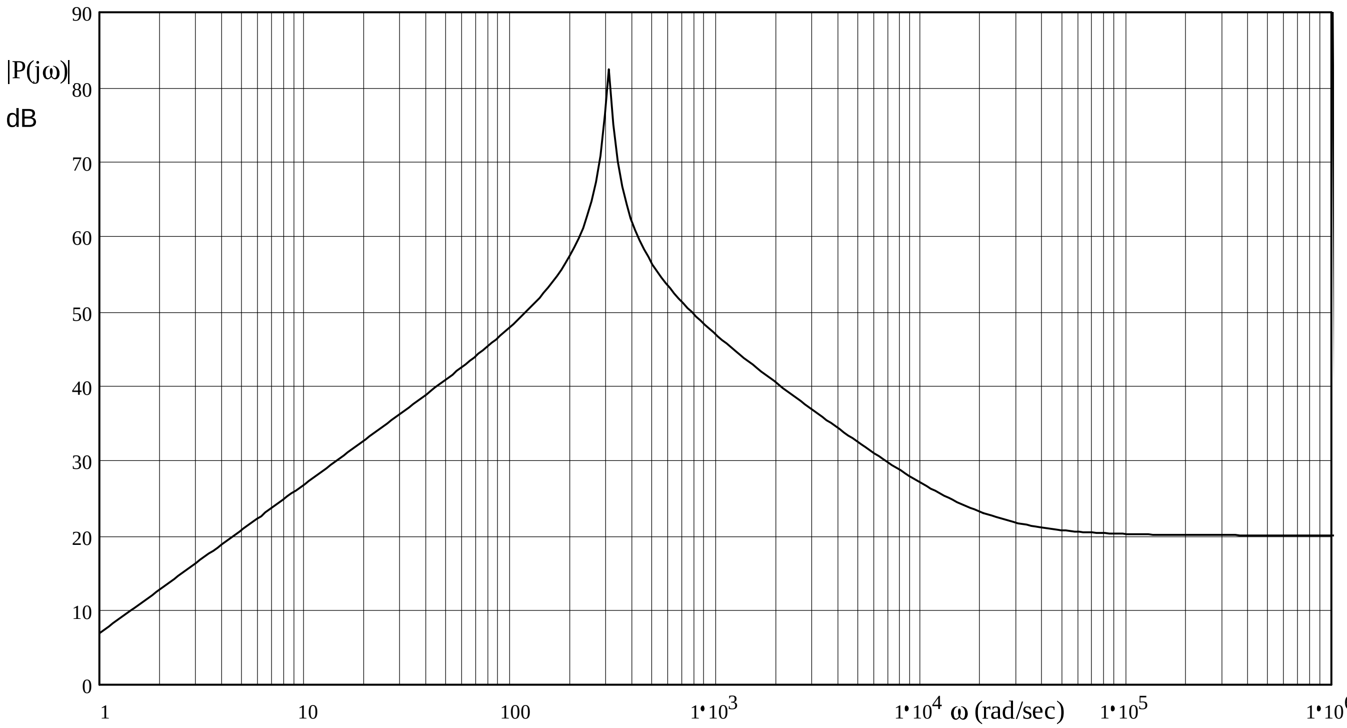
   a) Find the gain margin and phase margin of the closed-loop system. Show your work on the drawings.



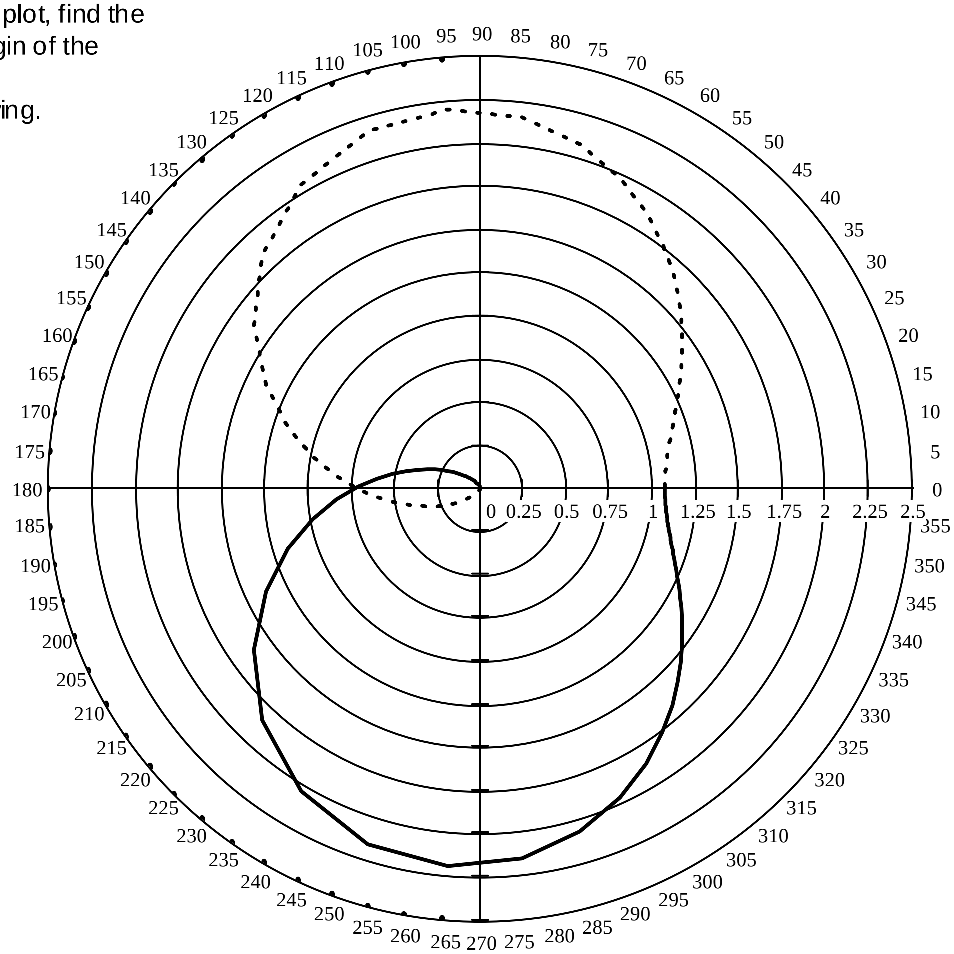


   b) Find the delay margin.

3. (17 pts) Given the magnitude Bode plot of a system, estimate the transfer function of the system. Assume there are no negative signs in the transfer function (all poles and zeros are in the left-half plane). Show yor work (how you made your estimate).



4. (6 pts) For the given Nyquist plot, find the gain margin and phase margin of the closed-loop system.
Show your work on the drawing.



5. (10 pts) An open-loop system has:

 1 unstable pole

 A DC gain of -4

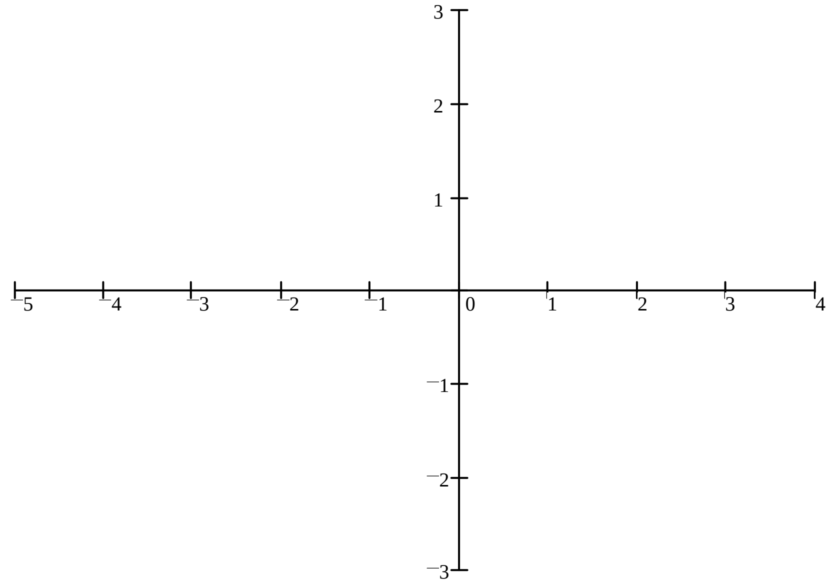
 3 more poles than zeros

The closed-loop gain margin is

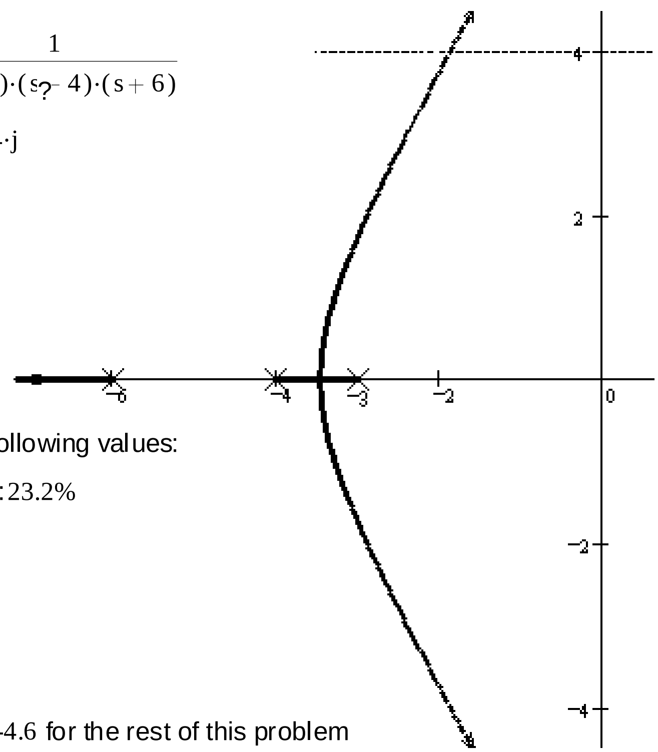
$$GM = \left[\frac{1}{3} \ , \ 2.5 \right]$$

Draw a possible Nyquist plot
for this system so that $Z = 0$.
You need only draw the ω>0 part.

label important points, like crossings



6. (33 pts) Consider the root-locus plot shown. $G(s) := \frac{1}{(s+3)\cdot(s ? 4)\cdot(s+6)}$



a) Does the root-locus pass through the point $s := -1.861 + 4\cdot j$

 Show your work or state what did in your calculator.

Assuming the closed-loop pole is at $-1.861 + 4j$ leads to the following values:

 Gain: 108.6 Settling time: $2.149\cdot sec$ Overshoot: 23.2%

 Steady-state error to a unit-step input: 39.9%

b) Add a compensator with a single zero
 so that the root locus will pass through $s := -4 + 4\cdot j$

Note: If you can't calculate the zero location, assume it is at -4.6 for the rest of this problem

c) With the compensator in place.

 i) What is the gain?

 ii) What is the 2% settling time? Use the second-order approximation.

 iii) What is the % overshoot? Use the second-order approximation.
 Show how to calculate this if you know a number by heart.

 iv) What is the steady-state error to a unit-step input?

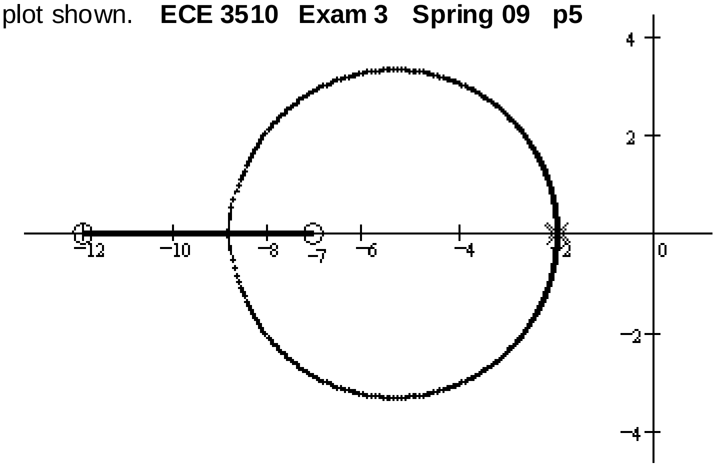
d) What improved with this compensation?

e) What is this type of compensator called?

f) Based on the numbers in part d), is there something that still needs improvement?
 If yes, what would you do to improve it?

g) The compensator of part b) is changed by moving the zero to the right and adding a pole so that the root locus still passes through $4 + 4j$. What is this new compensator called?

7. (10 pts) It looks like -9 is a break-in point for the root-locus plot shown.
   a) Determine if this is true, show work.



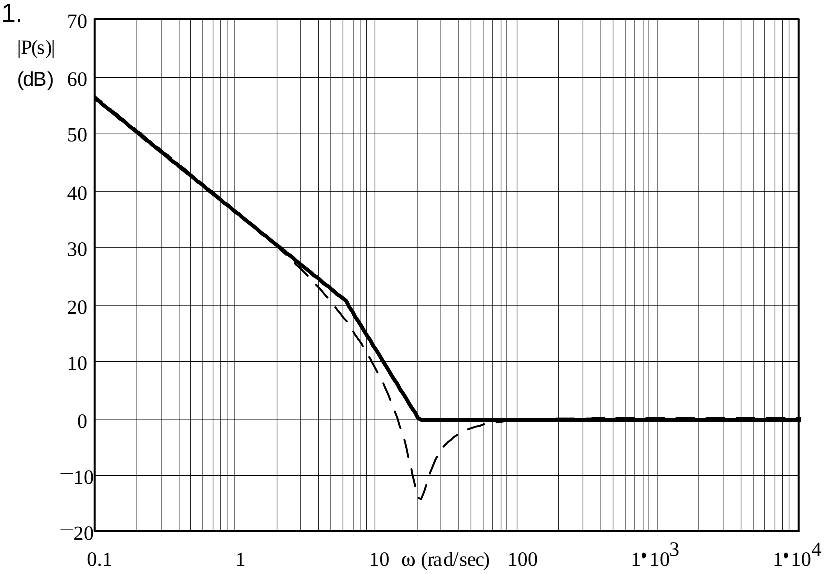
   b) Find the gain required to place a closed loop pole at -9.

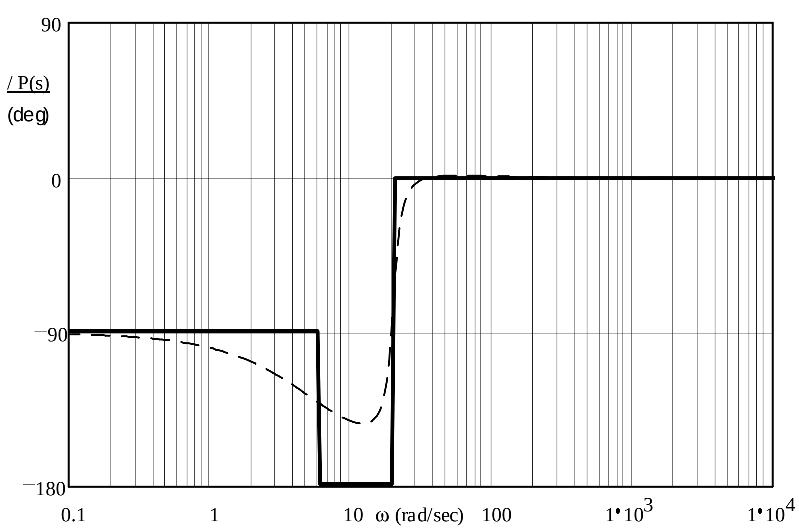
   c) Answer the following without making more calculations

The gain above: (of part b))
A) is LESS than the gain required to place the closed loop poles at break-in point.
B) IS the gain required to place the closed loop poles at break-in point.
C) is GREATER than the gain required to place the closed loop poles at break-in point.
D) It isn't possible to answer this without more calculations.

Answers

1.



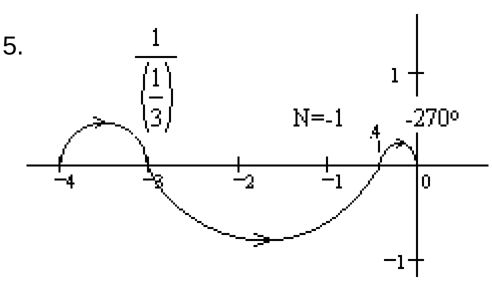


2. a) 15dB , 93º b) 116·ms

3. $P(s) = \dfrac{10 \cdot s \cdot (s + 20000)}{\left(s^2 + 15 \cdot s + 90000\right)}$

4. 4/3 , 93º

5.



6. a) arg(G(s)) = - 179.992 deg YES
   b) $C(s) := (s + 4.889)$
   c) i) 18 ii) 1·sec iii) 4.32·% iv) 45·%
   d) Speed and overshoot
   e) PD
   f) The steady-state error is awful. Add a PI or lag compensator
   g) Lead

7. a) NO, -9 is a NOT break-in point for the root-locus plot shown.
   b) 8.167
   c) C