Name: ______________________________ ECE 3510 homework Nq2 c

1. For problem Nq1, 2a (5.5 in Bodson text): $\mathbf{P}(s) = \dfrac{5\cdot(s+2)}{(s+1)^3}$

a) Find the DC gain ($s = 0 = \omega$) from the transfer function and compare it to the $\omega = 0$ point on the Nyquist diagram.

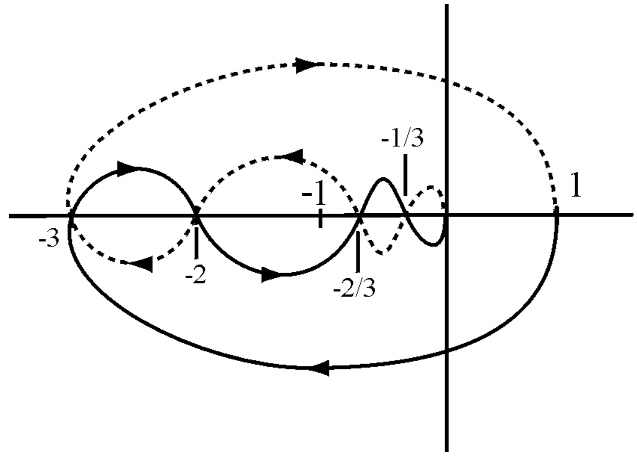
b) Find the final value ($\omega = \infty$) from the transfer function and compare it to the $\omega = \infty$ point on the Nyquist diagram.

c) Find the approach angle to the final value ($\omega = \infty$) from the transfer function and compare to the Nyquist diagram.

d) Reproduce the Nyquist diagram (left drawing). If you do this by hand, find and plot at least 3 more points (besides a & b, above) which will show the shape of the curve. You may also plot this diagram using a computer program of your choice.

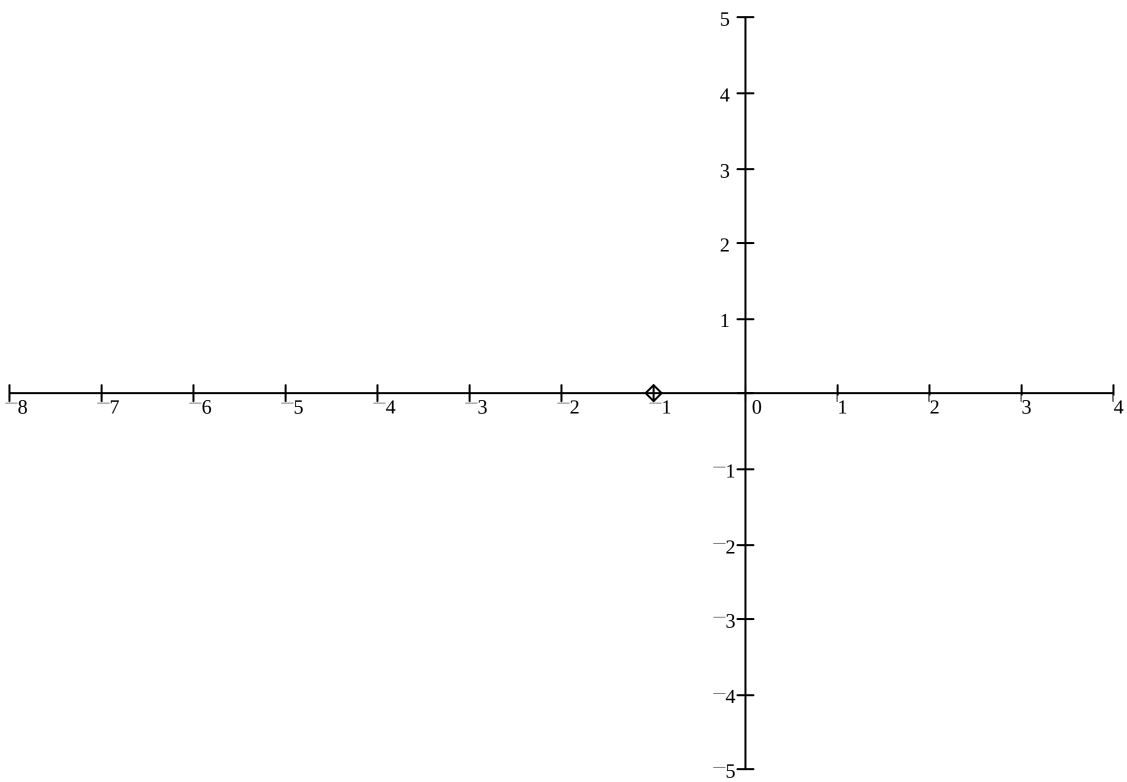
2. Problem 5.9 b - d in Bodson the text.

   b) Indicate whether the system whose Nyquist curve is shown is closed-loop stable, given that it is open-loop stable.



   c) What are the values of the gain $g > 0$ by which the open-loop transfer function of part (b) may be multiplied, with the closed-loop system being stable?

   d) Sketch an example of a Nyquist curve for a system which has three unstable open-loop poles, and which is closed-loop stable.



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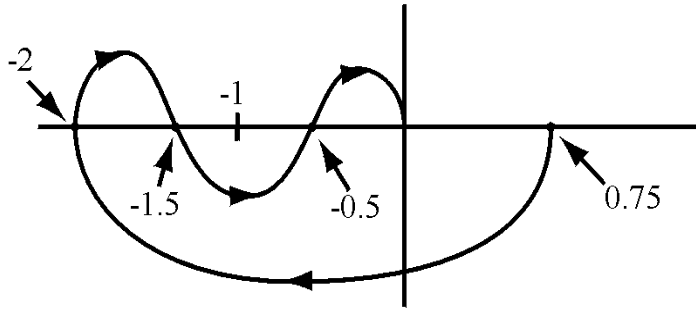
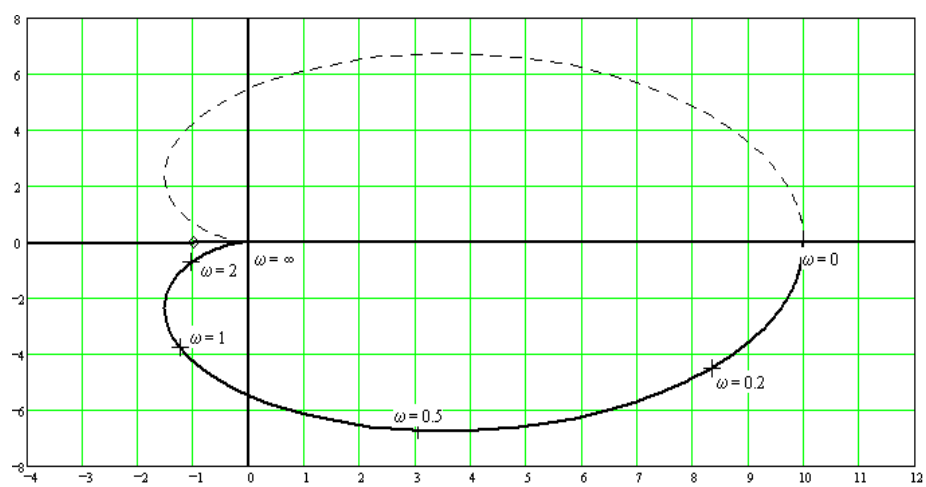
3. Problem 5.13 in the text.
   a) Consider the Nyquist diagram of a transfer function $\mathbf{G}(s)$ shown at right. Only the portion for $\omega > 0$ is plotted.

      Assume that $\mathbf{G}(s)$ has no poles in the open right-half plane, and that a gain K is cascaded with $\mathbf{G}(s)$. Find the ranges of positive K for which the closed-loop system is stable.



Answers

1. a) $\mathbf{P}(0) = 10$
   b) $\mathbf{P}(\infty) = 0$
   c) $-180 \cdot \deg$
   d) Extra points shown are for
      $s = 0.2j$,
      $s = 0.5j$,
      $s = 1j$,
      and $s = 2j$



2. b) yes c) $0 < g < \frac{1}{3}$, $\frac{1}{2} < g < \frac{3}{2}$ or $g > 3$ d) Need 3 CCW encirclements of -1
3. $k < \frac{1}{2}$, $\frac{2}{3} < k < 2$
4. a) yes b) GM $\simeq$ 2 $(6 \cdot dB)$ PM $\simeq 90 \cdot \deg$ c) 4 d) 4 , $3 \cdot \cos(t - 90 \cdot \deg)$, $-2 \cdot \cos(5 \cdot t)$
   e) $\frac{4}{3}$, $\frac{3 \cdot \sqrt{2}}{2} \cdot \cos(t - 45 \cdot \deg)$, $-4 \cdot \cos(5 \cdot t)$

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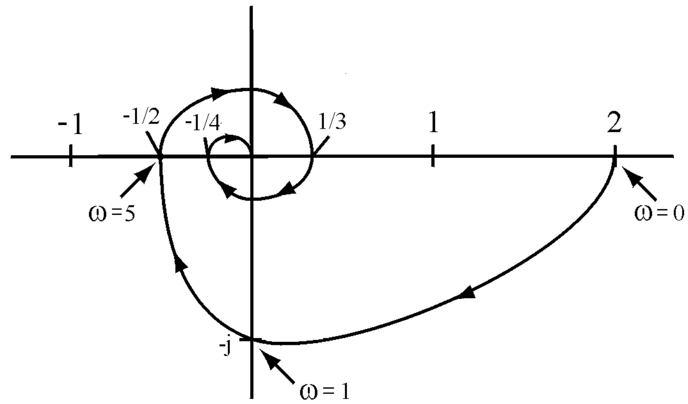
4. Problem 5.11 in the text.
   All parts of this problem refer to the system whose Nyquist curve is shown at right (only the portion for $\omega > 0$ is plotted). Recall that the Nyquist curve represents the frequency response of the open-loop system, or $\mathbf{G}(j\omega)$. If $\mathbf{G}(s)$ is the open-loop transfer function. The closed-loop transfer function is $\mathbf{G}(s)/(1 + \mathbf{G}(s))$.



   a) Knowing that the closed-loop system is stable, can one say for sure that the open-loop system is stable?

   b) Given the closed-loop system is stable, estimate the gain margin and the phase margin of the closed-loop system.

   c) How many unstable poles does the closed-loop system have if the open-loop gain is multiplied by 5?

   d) Give the steady-state response $y_{ss}(t)$ of the open-loop system to an input $x(t) = 2$.

   Repeat for $x(t)=3\cos(t)$

   and $x(t)=4\cos(5t)$.

   e) Repeat part (d) for the closed-loop system.
   Hint: remember that the output of the closed-loop system is $\text{input}\cdot\dfrac{\mathbf{G}(s)}{1+\mathbf{G}(s)}$

   $x(t)=3\cos(t)$

   $x(t)=4\cos(5t)$.