**16.060 - Principles of Automatic Control (F'02)**
**Final Exam**

Part C

C-1) You are given

$$G(s) \quad \frac{100(10s+1)}{s(s+1)(.1s+1)}$$

a) Sketch the log $|G|$ vs log ω

b) Sketch the $\angle$=G vs. log ω. What is the value at ω=10 r/s ?

C-2) For the open loop system

$$G(s) \quad \frac{k(s+4)}{(s+2)(s-4)(s^2+8s+32)}=$$

figure (a) is the pole zero diagram and figure (b) is the Nyquist diagram showing 3 regions of interest: A, B & C

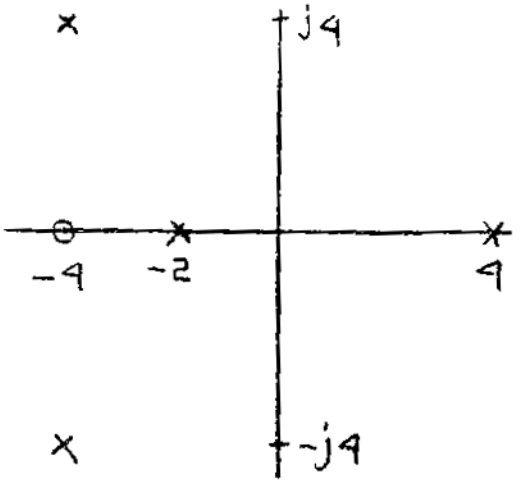



**Figure (a)**

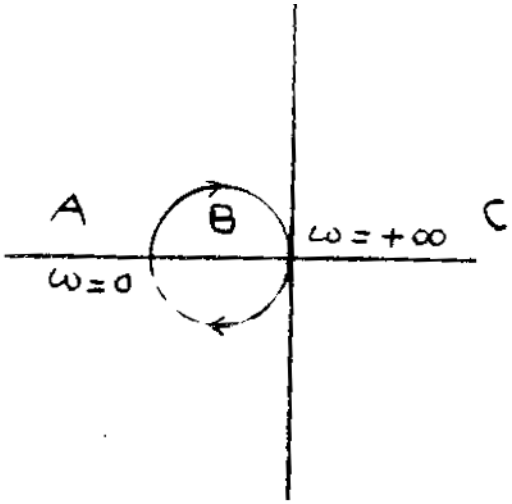



**Figure (b)**

a) Fill in table C-2

b) Sketch the branches which correspond to region C, the root locus

C-3) Figure C-3 is the Bode diagram of a certain G(s). What is the expression for G(s)?

C-4) Given

$$G(s) \quad \frac{K(1+s)^2}{(1-s)^2}$$

a) Sketch the Nyquist plot and the root locus for k>0 and k<0.
For the Nyquist plot use G(s)/k. Clearly show 0+, $+j\infty$, $-j\infty$, 0- and the direction of increasing frequency.

b) There will be four regions of interest (A,B,C,D left to right) in the Nyquist plot. Mark them.

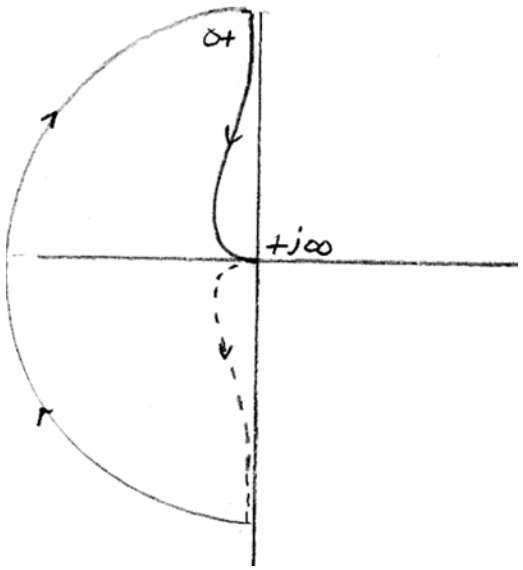
c) Show the $r - \lambda$ branches which correspond to regions B and D.

C-5) Estimate the phase margin and crossover frequency specifications to which a loop gain function must be designed if the closed-loop system must meet the following set of requirements:

A step response with an overshoot of 15% and a settling time of .5 sec.

C6) a) In doing a Nyquist stability analysis for a system which has, among other things, a pole at the origin and one zero in the r.h.p. the control engineer modifies the D contour by going around the pole at the origin in a clockwise sense. Now what is the correct equation for the Nyquist Stability Criterion?

b) The following is the Nyquist diagram for a certain G(s) which does not have poles or zeros in the r.h.p. What is a generic expression for G(s)?
<u>Use as few poles and zeros as possible</u>.



d) In old textbooks it is possible to find the following statement:

> *"In applying the Nyquist stability criterion, the closed loop system will be stable if there are no encirclements of the 1 point."*

Is this true or false?