AMERICAN UINVERSITY OF BEIRUT
FACULTY OF ENGINEERING AND ARCHITECTURE
EECE 460 Fall 2005-2006
Control Systems

Quiz I

Name:

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1.5 hours. Total of 100 points
Nov 1, Open Book Exam, 3 pages

YOU MUST RETURN THIS EXAM WITH YOUR ANSWER BOOKLET

Problem 1: (30 pts)
A ship has a mass m and a resistance C times the forward velocity u(t). The thrust from the propeller is K times its angular velocity w(t). The model is given by:

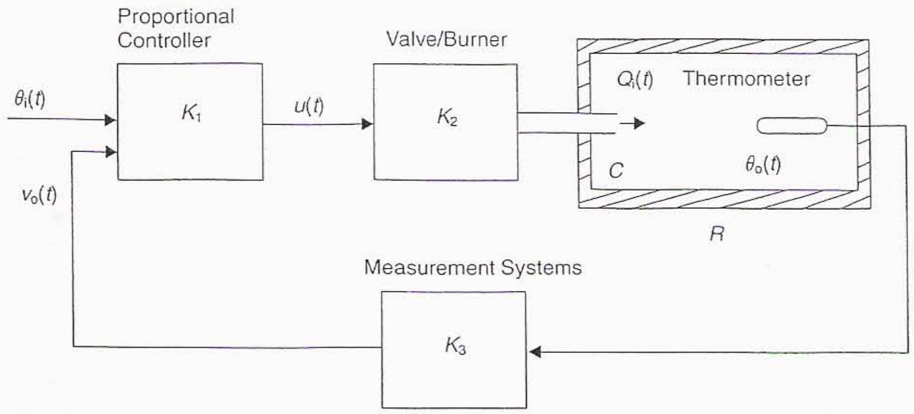
m (du/dt) + Cu(t) = Kw(t)

If m =18,000,000 Kg, C = 150,000 Ns/m and K = 96,000 Ns/rad:

+10 a) Determine the time constant of the system 120 Sec
+10 b) Assume the vessel is initially at rest, derive an expression for the time response of the ship when there is a step change of w(t) from 0 to 12.5 rad/s. $u(t) = 8(1 - e^{-0.0083}$
+10 c) What is the forward velocity after ten minutes. 7.94 m/sec

Problem 2: (30 pts)

The elements of a closed loop temperature control system are shown below.



A proportional controller compares the desired value $\theta_i(t)$ with the measured value V0(t) and provides a control signal u(t) of K1 times their difference to actuate the valve and burner unit. The heat input to the oven Qi(t) is K2 times the control signal. The walls of the oven have thermal resistance RT and the oven has a thermal capacitance CT and operating temperature $\theta o(t)$. The heat transfer equation for the oven may be written

$$Q_i(t) - \frac{\theta_{o(t)}}{R_T} = C_T \frac{d\theta_o}{dt}$$

The thermometer and measurement system feed a measured value of K3 times $\theta o(t)$ to the controller. The system parameters are:

K2 = 1.5 J/V K3 = 1 V/K
RT = 2 K/J CT = 25 Js/W

Determine:

+10 a) The open loop time constant 50 sec
+10 b) The P controller gain K1 so that the closed loop time constant is 3.125 sec. $K_1 = 5$
+10 c) The percentage steady-state error in the output when the desired value is constant. 6.25 %

Problem 3: (40 pts)

Consider the system shown below. Based on t supplied root loci for the system:

+7 a) Characterize the stability of the open loop system / Marginally Stable (One Pole $j\omega$)

+7 b) Characterize the stability of the closed loop system Conditionally stable (K dependent

+8 c) Approximate the double pole location(s) based on plot − 1 and − 1.6

+8 d) At double pole locations, can we approximate this 3[rd] order system by an equivalent 2[nd] order dominant one? Why. @ −1 yes since 3rd pole deeper −3; @ −1.6 NO since 3rd pole close to $j\omega$

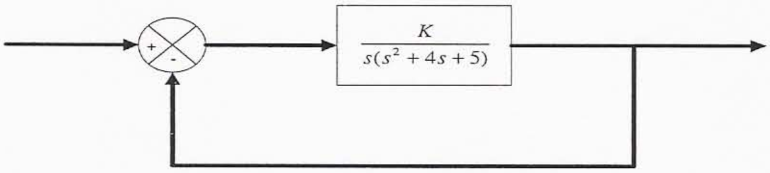
+5 e) Determine the value of K such that the damping ratio ζ of the dominant closed-loop poles is 0.5. K = 4.3 NOT UNIQUE

+5 f) Determine all closed-loop poles for the obtained system in (e).

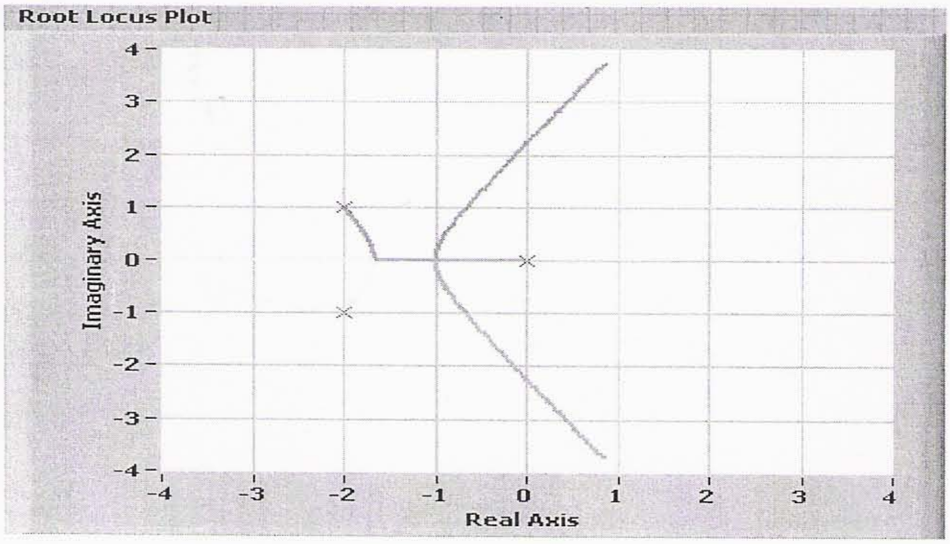
$s_1 = -2.75$

$s_2 = -0.65 + j1$

$s_3 = -0.65 - j1$



Control System



Corresponding Root locus plot