FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGERIA
SCHOOL OF ELECTRICAL ENGINEERING AND TECHNOLOGY
DEPARTMENT OF MECHATRONICS ENGINEERING
SECOND SEMESTER 2017/2018 B.Eng. DEGREE SEMESTER EXAMINATION
COURSE: MCE 324 Control System Design
INSTRUCTION: **Answer Any 2 Questions from Section A and Any 1 Question from Section B**
TIME ALLOWED: 3 Hours

SECTION A (Answer Any Two Questions in this section)

Question 1

(a) Using the Routh Hurwitz criterion, determine a range of values of the system parameter K for which the system A(s) below is stable [10 marks]

$$A(s) = s^3 + 3s^2 + 3s + 1 + K$$

(b) $$G(s) = s^5 + 2s^4 + 3s^3 + 6s^2 + 5s + 3$$

(i) What two methods can be used to determine the stability of a system with a zero in the first column of the Routh array? [4 marks]

(ii) Use any of the methods you have mentioned above to draw the Routh array of the given system G(s). [12 marks]

(iii) State and draw conclusions on the stability of the system based on your observations from (ii) above? [4 marks]

Question 2

(a) What is the effect of the addition of the following to a root locus?

(i) Poles [4 marks]

(ii) Zeros [4 marks]

(b) Given the system in the figure 1,

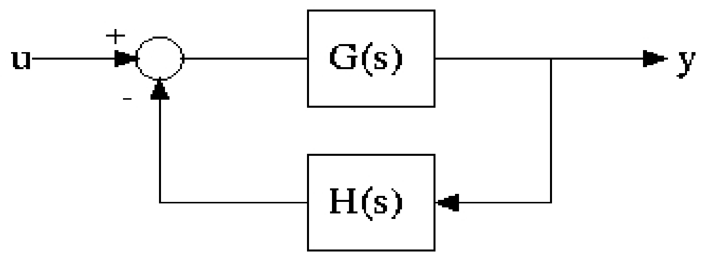

Figure.1

(i) Write out the closed loop transfer function of the system above? [2 marks]

(ii) What is the open loop transfer function of the system in the diagram above? [2 marks]

(iii) If the open-loop transfer function is given as

$$\frac{K_a}{s(s+3)(s^2+2s+2)}$$

Determine the number of asymptotes and the angles of the asymptotes? [7 marks]

(iv) Calculate the centroid of the asymptotes? [3 marks]

(v) Find the breakaway points for its root locus. [8 marks]

Question 3

(a) State 3 kinds of compensators you know and briefly describe each? [12 Marks]

(b) What are the main reasons why a system may need some form of compensation? [3 Marks]

(c) The characteristic equation of a system is given as;

$$G(s)H(s) = \frac{K(s-3)}{(s+2)}$$

(i) Add a pole at s=-1 and a zero at s=5 then write out the resulting function [3 marks]

(ii) Determine the breakaway and break-in points of the characteristic equation gotten in c(i) above [12 marks]

SECTION B (Answer only One Question in this section)

Question 4

(a) Using a well-illustrated diagram, develop the mathematical representation for a PI controller and the associated transfer function. [10 marks]

(b) With respect to the transient and steady state parameters, state the characteristics of the PI Controller. [10 marks]

(c) Identify the advantage and disadvantage of the PI controller. [5 marks]

(d) After the due completion of the MCE_Robot Arm, you are required to develop a PID controller using the Ziegler Nichols method for the system with transfer function.

$$G(s) = \frac{1}{s(s^2+6s+5)}$$ [15 marks]

Question 5

(a) State the characteristic of the PID controller with respect to the transient and Steady state properties. [10 marks]

(b) Describe the steps to follow in tuning a PID controller using the Ziegler Nichols continuous cycle technique. [5 marks]

(c) Obtain the PID controller Transfer function for the MCE Process system with transfer function defined by

$$G(s) = \frac{10}{3s+1}e^{-2s}$$ [15 marks]

(d) Derive the mathematical expression for a PID controller as well as its corresponding transfer function. [10 marks]

Additional information (Ziegler Nichols PID Tuning Table)

First Method

Type of Controller	K_p	T_i	T_d
P	$\frac{T}{L}$	∞	0
PI	$0.9\frac{T}{L}$	$\frac{L}{0.3}$	0
PID	$1.2\frac{T}{L}$	$2L$	$0.5L$

Second Method

Type of Controller	K_p	T_i	T_d
P	$0.5K_{cr}$	∞	0
PI	$0.45K_{cr}$	$\frac{1}{1.2}P_{cr}$	0
PID	$0.6K_{cr}$	$0.5P_{cr}$	$0.125P_{cr}$