FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGERIA
SCHOOL OF ELECTRICAL ENGINEERING AND TECHNOLOGY
DEPARTMENT OF MECHATRONICS ENGINEERING
SECOND SEMESTER 2018/2019 B.Eng. DEGREE EXAMINATION
COURSE: MCE 324: Control System Design

INSTRUCTION: Attempt All Questions

TIME: 3 Hours

Question One

The Robotic Arm system in the department is described by its transfer function depicted as Equation 4.

$$G(s) = \frac{1}{s(s^2 + 6s + 5)} \qquad (4)$$

a) With a well labelled, develop a mathematical representation for the PID controller to be used on the Robotic Arm (**5 Marks**)

b) State the characteristics features for the PID Controller with emphasis on the transient and steady state properties (**5 Marks**)

c) Develop a suitable PID Controller tuned using Ziegler Nichols approach for the robotic arm (**10 Marks**)

Question Two

In quest to unravel the cause of the crane collapse during the 2017 Hajj, a team of control engineers visited the site of the accident to ascertain the actual cause of the collapse. Preliminary investigation depicts the system model to be as depicted in Equation (1),

$$G(s) = \frac{2}{s^3 + 6s^2 + 12s + 8} \qquad (1)$$

a) Comment on the stability of the system using the based on the poles and zeros (**5 Marks)**
b) Comment on the stability of the system using the Routh Herwitz Criterion (**5 Marks)**

Question Three

The level controller for the water system in school of engineering was model as a first order system with delay and depicted as:

$$G(s) = \frac{2}{4s + 1}\, e^{-2s} \qquad (2)$$

You are required to:
a) Determine whether or not the system is stable. **(5 Marks)**

b) Develop for the system a PID controller tuned using the Ziegler Nichols approach. **(5 Marks)**

Question Four

Team XYZ are considering the use of root locus approach in analyzing their 3DOF robotic arm system with transfer function depicted as:

$$G(s)H(s) = \frac{K}{s(s+5)(s+10)} \qquad (2)$$

a) What are the effects of the additions of poles and zeros to a root locus? (**2 Marks**)

b) Consider the above system to be an open loop system, find the points of intersection with the imaginary axis in attempt to plot the root locus (**5 Marks**)

c) If the system model open loop transfer function was reduced to Equation 3, plot the root locus of the system (**3 Marks**)

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

Question Five

During the final installation of the lift system in the new Engineering Complex, it was discovered that there was a need to compensate the system model for optimal performance. Thus, you are required to answer the following:

a) What are the possible reasons that may have necessitated the need for compensation? (**5 Marks**)

b) Identify with brief description of any three (3) forms of compensator. (**5 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	$0.6K_{cr}$	$0.5P_{cr}$	$0.125P_{cr}$