The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Bachelor of Technology Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX6273 – Advanced control Systems**
Academic Year	:	2016/17
Date	:	24th November 2017
Time	:	0930hr-1230hr
Duration	:	3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **seven** questions.
3. **SECTION A, Answer Q1**, which is **compulsory**, and FOUR other questions selecting 2 from **SECTION B** and 2 from **SECTION C.**
4. State important, but relevant facts and information briefly and clearly. Where ever necessary, use neatly drawn sketches to explain answers.
5. Question 01 carries 40 marks whereas others each 15 marks.

SECTION A

Q1. (Spend approximately one hour)

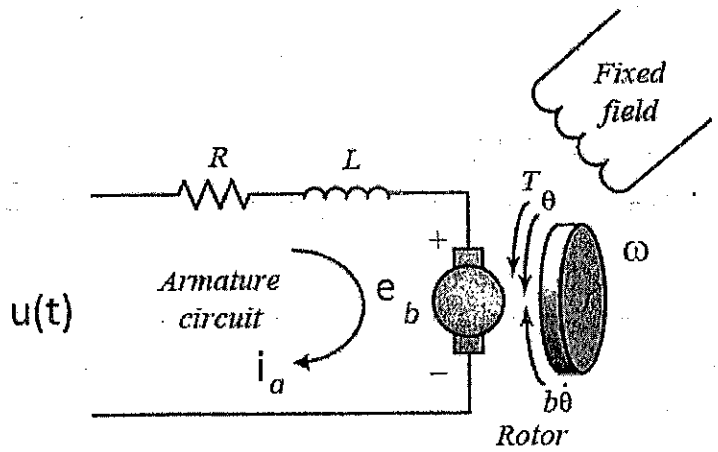

Figure Q1

The diagram of a separately excited dc motor speed control system is given in figure Q1. The load is driven by the separately excited dc motor. A dc tachogenerator is attached to the motor shaft which measures speed as the feedback signal, and the error signal is used to control the armature voltage of the

motor. The governing equations for the above system are given below. Parameters of the motor are as follows. R=1ohm, L=0.1H, J=0.1kgm^2, B=0.1Nm^{s-1}/rad , and T=T_b=0.1

$$u(t) = L\frac{di_a(t)}{dt} + Ri_a(t) + e_b(t)$$

$$T(t) = J\frac{d\omega(t)}{dt} + B\omega(t) = Ki_a(t)$$

$$e_b(t) = K_b\,\omega(t)$$

(a) Draw the block diagrams of the speed control and position control for the given motor control system. [10 marks]

(b) Derive the state space model for the speed control system of the motor. [10 marks]

(c) Derive the state space model for the position control system of the motor. [10 marks]

(d) Design a full order observer for the speed control system such that the observer poles are located at-6±j6 .Give all the relevant observer equations. [10 marks]

SECTION B

Q2.

(a) A function V(x) : Rn → R is described as positive definite. Explain what this means. [2 marks]

(b) A function V(x) is said to be radially unbounded. Explain what this means and why it is important in the study of stability using Lyapunov functions. [3 marks]

(c) A mass-spring-damper system with nonlinear damping is described by the following differential equations:

$$\dot{x_1} = x_2$$

$$\dot{x_2} = -\frac{K}{M}x_1 + \frac{B}{M}x_2(1 + x_2^2)$$

where K is the spring stiffness, B is the damping coefficient and M is the mass.

i) Linearize this system about the point $x_1 = x_2 = 0$ and give expressions for the "A" matrix of the system. [5 marks]

ii) Determine whether a symmetric positive definite solution exists to the following Lyapunov equation, where "A" is your answer to part i)

$$A'P+PA=-I$$

If it is solvable, find the matrix P. If not, explain your answer. [5 marks]

Q3.

Consider the system with the transfer function

$$\frac{Y(s)}{U(s)}=\frac{9}{s^2-9}$$

(a) Find the A, B, C for this system in the observable canonical form. [5 marks]

(b) Compute k so that the control law $u=-kx$ places the closed loop poles at $-3\pm j3$.

[5 marks]

(c) Design a full order observer such that the observer error poles are located at $-6\pm j6$ Give all the relevant observer equations. [5 marks]

Q4.

The open loop transfer function of second order system is given below

$$GH(z)=\frac{0.25K(z+0.71)}{(z-1)(z-0.36)}$$

(a) Obtain the root locus plot. [12 marks]

(b) Find the critical gain. [3 marks]

SECTION C

Q5.

A fuzzy set **A** in the universe **R** whose membership function is given by

$$\mu_A(x)=1-|x-2| \quad \text{for } |x-2|\le 1$$

$$=0 \text{ otherwise}$$

i) Sketch the membership function [5 marks]

ii) What is support set A? [5 marks]

iii) What is α-cut of A for α=0.5? [5 marks]

Q6.

(a) Draw an artificial neuron and label all the component in artificial neuron. [5 marks]

(b) The truth table of AND gate is given in table T6.

A	B	F
0	0	0
0	1	0
1	0	0
1	1	1

Table T6

This function can be implemented by a single-unit with two inputs:

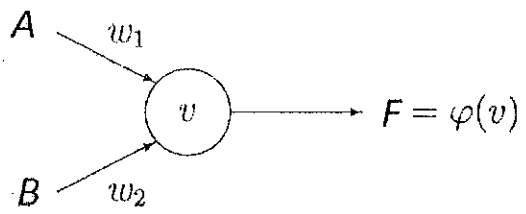

Figure Q6

if the weights are $w_1 = 1$ and $w_2 = 1$ and the activation function is:

$$\varphi(v) = \begin{cases} 1 & if\ v \geq 2 \\ 0 & otherwise \end{cases}$$

Note that the threshold level is 2 ($v \geq 2$).

i) Test how the neural AND function works. [5 marks]

ii) Suggest how to change either the weights or the threshold level of this single-unit in order to implement the logical OR function. [5 marks]

Q7.

(a) Describe in your own words the advantages of using fuzzy sets for describing an evolving taxonomy. [5 marks]

(b) Describe the key difference between a Mamdani controller and a Takagi-Sugeno-Kang Controller. [10 marks]

-END-