MACHAKOS UNIVERSITY

University Examination 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 514: CONTROL ENGINEERING II

DATE: 24/5/2019 **TIME: 8.30-10.30 AM**

QUESTION ONE (30 MARKS)

a) With aid of a circuit diagram derive the expression of the output of a proportional controller. (6 marks)

b) Describe the following terms:

i. Controllability

ii. Observability (4 marks)

c) With aid of diagram, explain why derivative controller is never used alone. (3 marks)

d) The circuit in fig.4 is a schematic diagram representing a dc motor and load. The field is maintained constant. Determine the state equations in the vector matrix form for the state variable$x1 = \theta,\ x2 = \frac{d\theta}{dt}$ and $x3 = \frac{d^2\theta}{dt^2}$. Assume:

Moment of inertia of motor and load $=j$

Back emf contstant $=kb$

Coefficient of friction of motor and load $=f$

Motor torque constant $=K_T$ (10 marks)

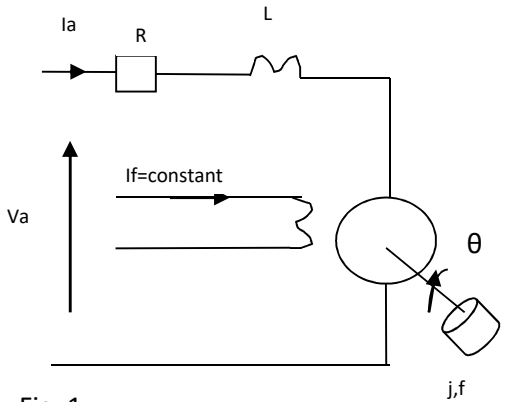

Fig. 1

e) Construct the state model for a system characterized by the differential equation below and give the block diagram representation. (7 marks)

$$5u = \frac{d^4y}{dt^4} + 10\frac{d^3y}{dt^3} + 20\frac{d^2y}{dt^2} + 30\frac{dy}{dt} + 40y$$

QUESTION TWO (20 MARKS)

a) With aid of a diagram derive the expression of the output of a derivative controller (5 marks)

b) Briefly discuss any two common physical no- linearlities. (4 marks)

c) Sketch a labeled block diagram representation of the state model. (5 marks)

d) The circuit in fig.2 is an integrator. VC=0 at t=0. A step input of Vi=-2 is applied at t=0. Determine the time constant such that the output reaches +20 volts at t=2mS. (6 marks)

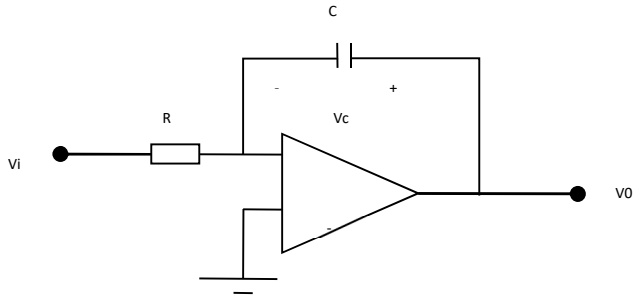

Fig2

QUESTION THREE (20 MARKS)

a) With aid of a circuit diagram derive the expression of the output of a proportional plus integral controller. (6 marks)

b) Determine the values of R1 and R2 of an electronic proportional plus integral controller with a proportional gain of 4 and integral action of 40 seconds. Use 10 microfarad capacitor. If the controller has an output of 40% at time t=0. Using error graph in fig.3, determine controller output for the following times:

i. At t=20 seconds.

ii. At t=60 seconds. (8 marks)

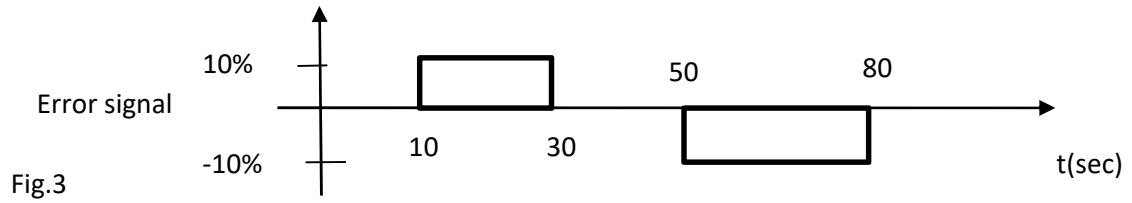

Fig.3

c) When using canonical state model, diagonalization of matrix is necessary. This is facilitated by use of eigenvectors. Let $A = \begin{pmatrix} 10 & -8 \\ 4 & -2 \end{pmatrix}$. Find all eigenvalues of A.(6 marks)

QUESTION FOUR (20 MARKS)

a) Briefly describe system optimal control (3 marks)

b) The diagram in fig.4 shows the relationship between solutions's controlled temperature and percentage gas valve opening. Given proportional controller has controller range between 40°C and 240°C. Determine the percentage proportional band. (7 marks)

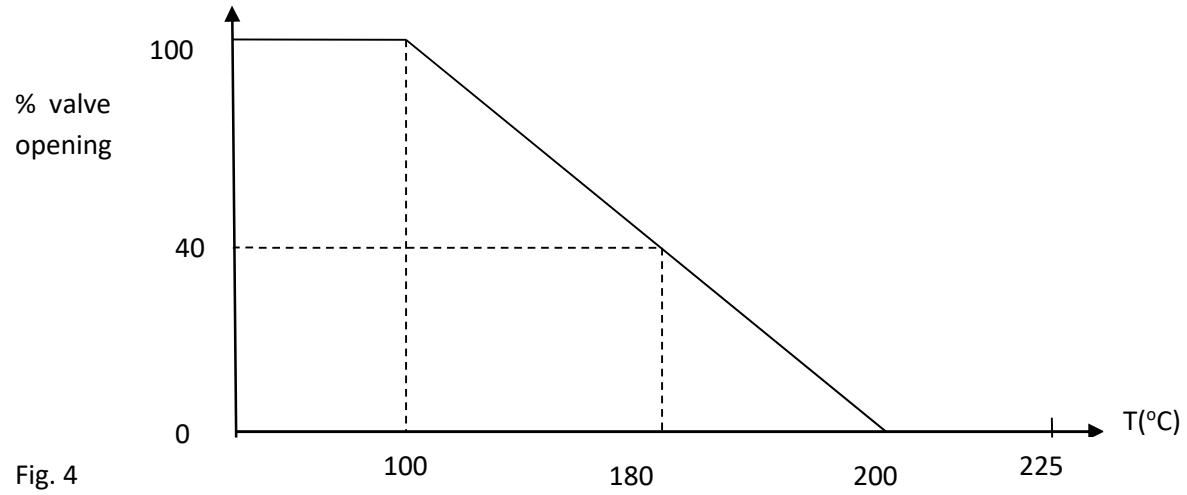

Fig. 4

c) The waveform in fig.5 shows an input signal. Assuming zero initial conditions, sketch the output waveforms when the given signal is applied to:

i. Proportional controller
ii. Integral controller
iii. Derivative controller
iv. Proportional plus integral controller
v. Proportional plus derivative controller (10 marks)

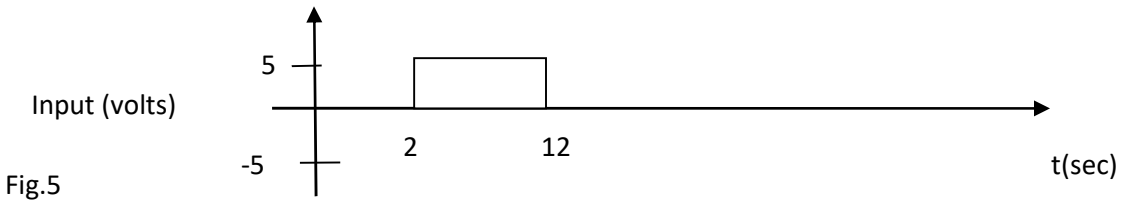

Fig.5

QUESTION FIVE (20 MARKS)

a) With aid of a diagram briefly describe adaptive controller. (5 marks)

b) Briefly explain what is meant by 'the state of a dynamic system'. (2 marks)

c) The state of the system in fig.6 at any time, t, is given by variables x(t) and v(t) which are state variables of the system. Derive expression of displacement x(t) at any time $t \geq 0$. Initial velocity is v(t0) and initial displacement is x(t0). F(t) is the input variable from t=t0. (10 marks)

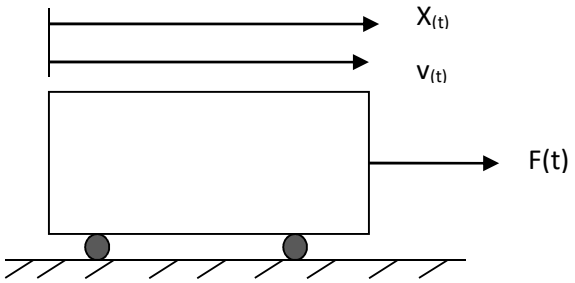

Fig. 6

d) With aid of expressions explain the difference between time invariant and time varying systems. (3 marks)