MACHAKOS UNIVERSITY

University Examinations for 2016/2017

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

THIRD YEAR SECOND SEMESTER EXAMINATION FOR DEGREE IN

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EEE 311: CONTROL II

DATE: 13/6/2017 **TIME: 2 HRS**

INSTRUCTIONS

Answer Question One and Any Other Two Questions

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Briefly discuss why control systems are compensated. (3 marks)

b) Mention any THREE comparisons between phase lead and phase lag compensator. (3 marks)

c) Design a phase lead compensating network to achieve a phase margin of 40º for a system whose transfer function is given by: (9 marks)

$$G(s) = \frac{10}{S(1+0.5S)(1+0.01S)}$$

d) Explain why derivative controller is never used alone. (2 marks)

e) The waveform in fig.1shows 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 (8 marks)

Fig.1

f) Construct the state model for a system characterized by the differential equation below and give the block diagram representation. (5 marks)

$$5u = \frac{d^4y}{dt^4} + 10\frac{d^3y}{dt^3} + 15\frac{d^2y}{dt^2} + 20\frac{dy}{dt} + 30y$$

QUESTION TWO (20 MARKS)

a) Design a phase lag compensating network to achieve a phase margin of 35^o for a system whose transfer function is given by: (9 marks)

$$G(s) = \frac{17.783}{S(1 + 0.5S)(1 + 0.05S)}$$

b) Sketch a block diagram representation of the state model. (3 marks)

c) 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. (8 marks)

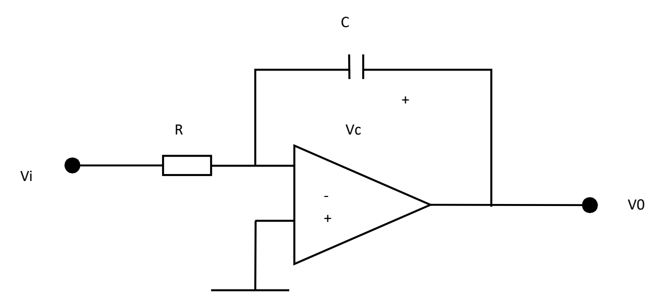

Fig2

QUESTION THREE (20 MARKS)

a) For a lead lag compensator network:
   i. Sketch a well labeled diagram.
   ii. Derive expression of the transfer function.
   iii. Sketch its Bode plot.
   iv. From the Bode plot discuss how it is used to compensate a system. (9 marks)

b) With aid of a diagram derive the expression of the output of a proportional plus integral controller. (5 marks)

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) With aid of diagrams differentiate between cascaded and feedback compensated systems. (5 marks)

b) Discuss advantage of operational amplifier based compensating networks. (2 marks)

c) The diagram in fig.3 shows the relationship between solutions's controlled temperature and percentage gas valve opening. Given proportional controller has controller range between 40ºC and 240ºC. Determine the percentage proportional band. (4 marks)

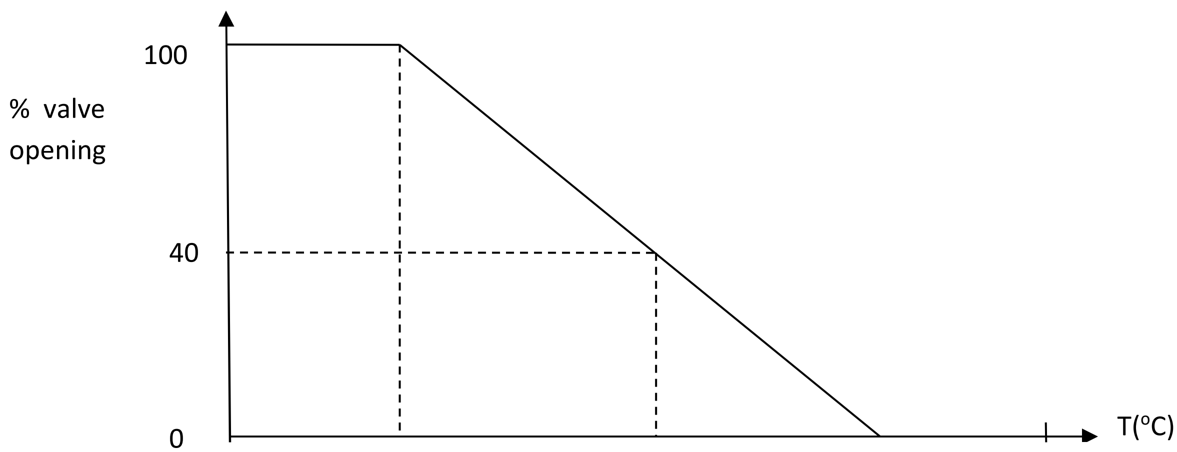

Fig. 3

d) For the system shown in fig. 4, choose v1(t) and v2(t) as the state variables. Determine the state equations in the vector matrix form. (9 marks)

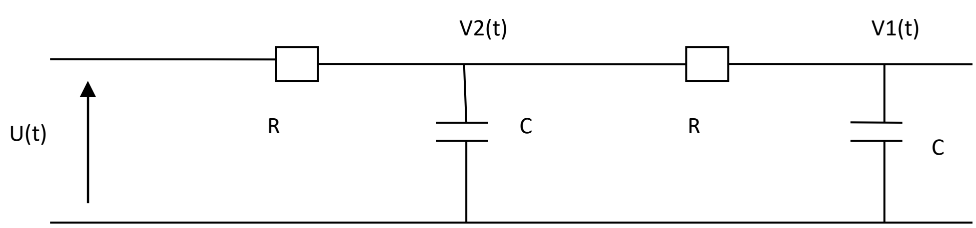

Fig. 4

R=1MΩ, C=μF

QUESTION FIVE (20 MARKS)

a) The bode plot in fig.5 is for a phase lead network. Given that ω_M is geometrical mean of the two corner frequencies derive its expression. (5 marks)

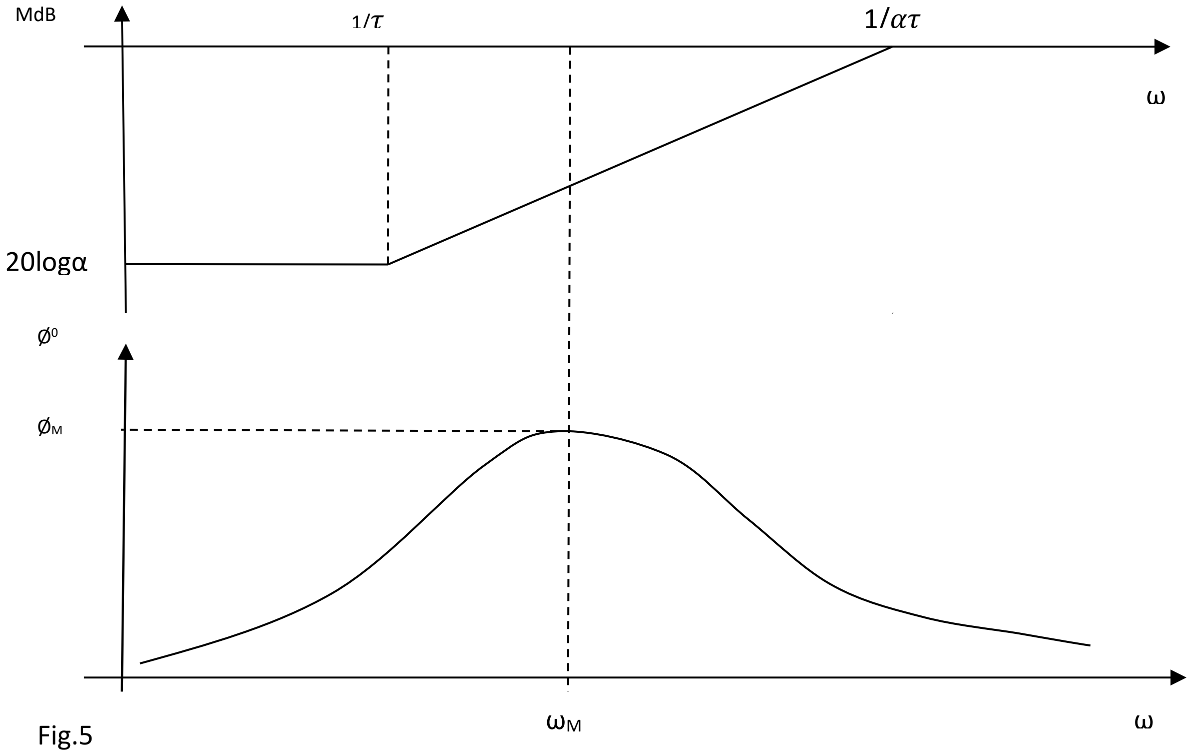

Fig.5

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≥0. Initial velocity is v(t0) and initial displacement is x(t0). F(t) is the input variable from t=t0. (10 marks)

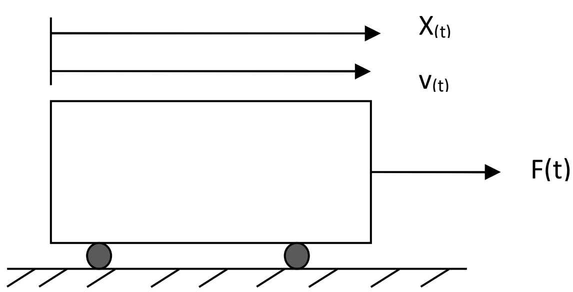

Fig. 6

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