BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ENGINEERING AND PHYSICS

Bachelor of Science Honours Degree in Electronic Engineering

EEE4203/EEE5104: MODERN CONTROL ENGINNERING

Duration: 3 Hours **Total Marks: 100**

Special Requirements: Scientific Calculator, rule, pen, pencil

INSTRUCTIONS TO CANDIDATES

1. Answer any **five (5)** questions
2. The question paper contains **SEVEN (7)** questions
3. Each question carries 20 marks

1(a) Find the rank of the matrix by the determinant method **[3]**

$$A = \begin{bmatrix} 2 & 3 & 4 \\ 4 & 3 & 1 \\ 1 & 2 & 4 \end{bmatrix}$$

(b) Find the adjoint of matrix A where **[12]**

$$\boldsymbol{A} = \begin{bmatrix} 1 & 0 & 3 \\ 2 & 4 & 1 \\ 3 & 2 & 2 \end{bmatrix}$$

(c) Explain the concept of state and state variable in state space analysis **[4]**

(b) Define input of a control system **[1]**

2(a) Sketch the basic elements that are used to construct a block diagram of state model and explain the function of each element. **[3+3+3]**

(b) Draw the block diagram representation of a state model **[5]**

(c) How many state variables, inputs and outputs are there in the system below? **[2+2+2]**

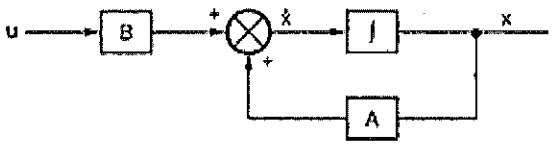
$$\dot{x} = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix} x + \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix} u, \quad y = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix} x + \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} u$$

3(a) Sketch the basic elements that are used to construct the signal flow graph of a system in the domain of your choice. **[3+3+3]**

(b) Draw signal flow graph representation of state model **[5]**

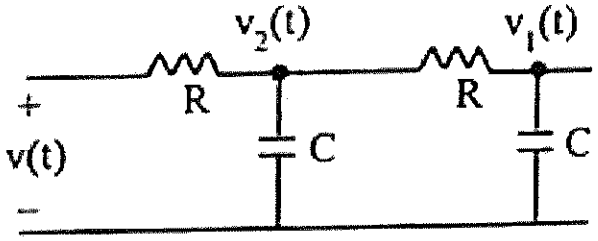
(c) Using your knowledge of circuit analysis, write down the formula for finding the voltage and current across and through a capacitor respectively. **[2+2]**

(d) According to state variable feedback explain why the system below is referred to as open loop control system **[2]**



Open loop control system

4 Obtain the state model of the electrical network shown below. **[20]**



5(a)(i) State feedback enables control system design by pole placement. What are the two state model of a two systems? **[2]**

(ii) Draw the state diagrams of the two above systems. **[8]**

(b) A single input system is described by the following state equation

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix} = \begin{bmatrix}-1 & 0 & 0\\ 1 & -2 & 0\\ 2 & 1 & -3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix} + \begin{bmatrix}10\\ 1\\ 0\end{bmatrix}u$$

Check the system for controllability **[7]**

(c) State three characteristics of non-linear control systems **[3]**

6(a) The response of a system is $y = ax^2 + e^{bx}$. Test whether the system is linear or nonlinear. **[15]**

(b) Determine the Z transform of unit step signal **[5]**

7 Consider a linear system described by the transfer function

$$\frac{Y(s)}{U(s)} = \frac{10}{s(s+1)(s+2)}$$

(a) Find state equations governing the system **[7]**

(b) Convert state equations to matrix form **[2]**

(c) Check controllability of the system **[7]**

(d) Find K_C^{-1} **[4]**

THE END OF PAPER