Code No.: 16339 AS

## VASAVI COLLEGE OF ENGINEERING (AUTONOMOUS), HYDERABAD

Accredited by NAAC with A++ Grade

## B.E. (E.E.E.) VI-Semester Advanced Supplementary Examinations, August-2022 Control Systems

Time: 3 hours

Max. Marks: 60

Note: Answer all questions from Part-A and any FIVE from Part-B

Part-A  $(10 \times 2 = 20 \text{ Marks})$ 

| Stem of the question   | M  | L  | CO   | PO   |
|--|--|--|--|--|
| Compare the negative feedback system and positive feedback system.   | 2  | 1  | 1  | 1,2  |
| Define the following terms with suitable examples; i) System, ii) Control System, iii) Open loop system, iv) Closed loop system.   | 2  | 1  | 1  | 1,2  |
| Define rise time, settling time, maximum overshoot and peak time of the system.  | 2  | 1  | 2  | 1,2  |
| Consider a system $G(s) = \frac{(s+20)}{s^2(s^2+9s+24)}$ with unit feedback. Calculate the error constants $(K_p, K_p, K_a)$ and the system type.  | 2  | 2  | 2  | 1,2  |
| Define the resonant peak of the system.  | 2  | 1  | 3  | 1,2  |
| Explain the concept of relative stability analysis of the system.  | 2  | 2  | 3  | 1,2  |
| Compare Bode plot and Nyquist plot based system analysis.  | 2  | 1  | 4  | 1,2  |
| State the principle of argument.   | 2  | 1  | 4  | 1,2  |
| Compare the state space approach and the transfer function approach.   | 2  | 2  | 5  | 1,2  |
| Write any two properties of state transition matrix.   | 2  | 2  | 5  | 1,2  |
| Part-B $(5 \times 8 = 40 \text{ Marks})$   |  |  |  |  |
| Compare the merits & demerits of Block diagram reduction technique and Signal Flow Graph approach  | 4  | 2  | 1  | 1,2  |
| Find the closed loop transfer function $\frac{C(s)}{R(s)}$ of the diagram shown below using the block diagram reduction technique  | 4  | 3  | 1  | 1,2  |
| $H_1$  |  |  |  |  |
| $R(s)$ $G_1$ $G_2$ $G_3$ $G_3$ $G_4$ $G_4$ $G_5$ $G_4$ $G_5$ $G_7$ $G_8$ $G_8$ $G_9$ |  |  |  |  |
|  | Compare the negative feedback system and positive feedback system. Define the following terms with suitable examples; i) System, ii) Control System, iii) Open loop system, iv) Closed loop system. Define rise time, settling time, maximum overshoot and peak time of the system.  Consider a system $G(s) = \frac{(s+20)}{s^2(s^2+9s+24)}$ with unit feedback. Calculate the error constants $(K_p, K_v, K_a)$ and the system type.  Define the resonant peak of the system.  Explain the concept of relative stability analysis of the system.  Compare Bode plot and Nyquist plot based system analysis.  State the principle of argument.  Compare the state space approach and the transfer function approach.  Write any two properties of state transition matrix.  Part-B $(5 \times 8 = 40 \text{ Marks})$ Compare the merits & demerits of Block diagram reduction technique and Signal Flow Graph approach  Find the closed loop transfer function $\frac{C(s)}{R(s)}$ of the diagram shown below using the block diagram reduction technique | Compare the negative feedback system and positive feedback system.  Define the following terms with suitable examples; i) System, ii) 2 Control System, iii) Open loop system, iv) Closed loop system.  Define rise time, settling time, maximum overshoot and peak time of the system.  Consider a system $G(s) = \frac{(s+20)}{s^2(s^2+9s+24)}$ with unit feedback. Calculate the error constants $(K_p, K_v, K_a)$ and the system type.  Define the resonant peak of the system.  Explain the concept of relative stability analysis of the system.  Compare Bode plot and Nyquist plot based system analysis.  State the principle of argument.  Compare the state space approach and the transfer function approach.  Write any two properties of state transition matrix.  Part-B $(5 \times 8 = 40 \text{ Marks})$ Compare the merits & demerits of Block diagram reduction technique and Signal Flow Graph approach  Find the closed loop transfer function $\frac{C(s)}{R(s)}$ of the diagram shown below using the block diagram reduction technique | Compare the negative feedback system and positive feedback system.  Define the following terms with suitable examples; i) System, ii)  Control System, iii) Open loop system, iv) Closed loop system.  Define rise time, settling time, maximum overshoot and peak time of the system.  Consider a system $G(s) = \frac{(5+20)}{s^2(s^2+9s+24)}$ with unit feedback. Calculate the error constants $(K_p, K_v, K_a)$ and the system type.  Define the resonant peak of the system.  Explain the concept of relative stability analysis of the system.  Compare Bode plot and Nyquist plot based system analysis.  State the principle of argument.  Compare the state space approach and the transfer function approach.  Write any two properties of state transition matrix. $Part-B (5 \times 8 = 40 \ Marks)$ Compare the merits & demerits of Block diagram reduction technique and Signal Flow Graph approach  Find the closed loop transfer function $\frac{C(s)}{R(s)}$ of the diagram shown below using the block diagram reduction technique | Compare the negative feedback system and positive feedback system.  Define the following terms with suitable examples; i) System, ii) Control System, iii) Open loop system, iv) Closed loop system.  Define rise time, settling time, maximum overshoot and peak time of the system.  Consider a system $G(s) = \frac{(s+20)}{s^2(s^2+9s+24)}$ with unit feedback. Calculate the error constants $(K_p, K_p, K_a)$ and the system type.  Define the resonant peak of the system.  Explain the concept of relative stability analysis of the system.  Compare Bode plot and Nyquist plot based system analysis.  Compare the state space approach and the transfer function approach.  Write any two properties of state transition matrix.  Part-B $(5 \times 8 = 40 \text{ Marks})$ Compare the merits & demerits of Block diagram reduction technique and Signal Flow Graph approach  Find the closed loop transfer function $\frac{C(s)}{R(s)}$ of the diagram shown below using the block diagram reduction technique |

| Determine the range of $K$ for stability using the Routh-Hurwitz stability criterion.  b) Draw the rough sketch of the root locus (with the detailed steps) of open loop transfer function given as $G(s)H(s) = \frac{K}{s(s+1)(s^2+4s+5)}; H(s) = 1$ Also find out the imaginary axis crossing point and indicate it in the rough sketch.  13. a) Compare the frequency response and time response of a system. Define Bandwidth of the system.  b) Draw the Bode diagram (asymptotic magnitude plot and Phase plot) for the following transfer function with the detailed steps $G(s) = \frac{2500(s+11)}{s(s+3)(s^2+30s+2500)}$ 14. a) State the Nyquist stability criterion.  b) Consider a unity-feedback control system with the following open-loop transfer function $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps  15. a) Define a state and state transition matrix of the system.  b) Consider the system defined by $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \vdots \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u;$ $y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ Is the system completely controllable and completely observable?  | 12. a)     | Consider the following characteristic equation $s^4 + 2s^3 + (4 + K)s^2 + 9s + 25 = 0$         | 3 | 3 | 2 | 1,2 |
|--|------------|--|---|---|---|-----|
| loop transfer function given as $G(s)H(s) = \frac{K}{s(s+1)(s^2+4s+5)}; H(s) = 1$ Also find out the imaginary axis crossing point and indicate it in the rough sketch.  13. a) Compare the frequency response and time response of a system. Define Bandwidth of the system.  b) Draw the Bode diagram (asymptotic magnitude plot and Phase plot) for the following transfer function with the detailed steps $G(s) = \frac{2500 \ (s+11)}{s(s+3)(s^2+30s+2500)}$ 14. a) State the Nyquist stability criterion.  b) Consider a unity-feedback control system with the following open-loop transfer function $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps  15. a) Define a state and state transition matrix of the system.  b) Consider the system defined by $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 0 \\ 1 \end{bmatrix} u;$ $y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$   | and the se |  |   |   |   |     |
| Also find out the imaginary axis crossing point and indicate it in the rough sketch.  13. a) Compare the frequency response and time response of a system. Define Bandwidth of the system.  b) Draw the Bode diagram (asymptotic magnitude plot and Phase plot) for the following transfer function with the detailed steps $G(s) = \frac{2500 (s+11)}{s(s+3)(s^2+30s+2500)}$ 14. a) State the Nyquist stability criterion.  Consider a unity-feedback control system with the following open-loop transfer function $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps  15. a) Define a state and state transition matrix of the system. $\left[\frac{x_1}{x_2}\right] = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 0 \\ 1 \end{bmatrix} u;$ $y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$  | b)         |  | 5 | 3 | 2 | 1,2 |
| rough sketch.  13. a) Compare the frequency response and time response of a system. Define Bandwidth of the system.  b) Draw the Bode diagram (asymptotic magnitude plot and Phase plot) for the following transfer function with the detailed steps $G(s) = \frac{2500 (s+11)}{s(s+3)(s^2+30s+2500)}$ 14. a) State the Nyquist stability criterion. $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps  15. a) Define a state and state transition matrix of the system. $G(s) = \frac{K}{s(s+1)(s+2)}$ Consider the system defined by $G(s) = \frac{K}{s(s+1)(s+2)}$ $G(s) = \frac{K}{s(s+2)(s+2)}$ $G(s)$                              | 3          | $G(s)H(s) = \frac{K}{s(s+1)(s^2+4s+5)}; H(s) = 1$  |   |   |   |     |
| rough sketch.  13. a) Compare the frequency response and time response of a system. Define Bandwidth of the system.  b) Draw the Bode diagram (asymptotic magnitude plot and Phase plot) for the following transfer function with the detailed steps $G(s) = \frac{2500 (s+11)}{s(s+3)(s^2+30s+2500)}$ 14. a) State the Nyquist stability criterion. $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps  15. a) Define a state and state transition matrix of the system. $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 0 \\ 1 \end{bmatrix} u;$ $y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$   |            | wildpen hop system, in: Orean's isogrey soun   |   |   |   |     |
| Bandwidth of the system.  b) Draw the Bode diagram (asymptotic magnitude plot and Phase plot) for the following transfer function with the detailed steps $G(s) = \frac{2500 (s+11)}{s(s+3)(s^2+30s+2500)}$ 14. a) State the Nyquist stability criterion. $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps  15. a) Define a state and state transition matrix of the system. $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps  15. a) Define a state and state transition matrix of the system. $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps $G(s) = \frac{K}{s(s+1)(s+2)}$ $G(s) = \frac$   |            |  |   |   |   |     |
| the following transfer function with the detailed steps $G(s) = \frac{2500 \ (s+11)}{s(s+3)(s^2+30s+2500)}$ 14. a) State the Nyquist stability criterion. $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps  15. a) Define a state and state transition matrix of the system. $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps  15. a) $G(s) = \frac{K}{s(s+1)(s+2)}$ $G(s) = \frac{K}{s(s+2)(s+2)}$ $G(s) = \frac{K}{s(s+2)(s+2$ | 13. a)     |  | 4 | 2 | 3 | 1,2 |
| 14. a) State the Nyquist stability criterion.  b) Consider a unity-feedback control system with the following open-loop transfer function $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps  15. a) Define a state and state transition matrix of the system.  4 2 4 1,2  4 3 4 1,2  1,2  1,2  1,3  1,5  1,5  1,6  1,7  1,7  1,8  1,9  1,9  1,9  1,9  1,9  1,9  1,9   | b)         |  | 4 | 3 | 3 | 1,2 |
| 14. a) State the Nyquist stability criterion.  b) Consider a unity-feedback control system with the following open-loop transfer function $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps  15. a) Define a state and state transition matrix of the system.  4 2 4 1,2  4 3 4 1,2  1,2  1,2  1,3  1,5  1,5  1,6  1,7  1,7  1,8  1,9  1,9  1,9  1,9  1,9  1,9  1,9   |            | $G(s) = \frac{2500(s+11)}{s}$  |   |   |   |     |
| Consider a unity-feedback control system with the following open-loop transfer function $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps  15. a) Define a state and state transition matrix of the system.  4 2 5 1,2  Consider the system defined by $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u;$ $y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$  |            | $s(s+3)(s^2+30s+2500)$   |   |   |   |     |
| transfer function $G(s) = \frac{K}{s(s+1)(s+2)}$ Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps  15. a) Define a state and state transition matrix of the system.  4 2 5 1,2  b) Consider the system defined by $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u;$ $y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$   | 14. a)     | State the Nyquist stability criterion.   | 4 | 2 | 4 | 1,2 |
| Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps  15. a) Define a state and state transition matrix of the system.  4 2 5 1,2  b) Consider the system defined by $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u;$ $y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$  | b)         |  | 4 | 3 | 4 | 1,2 |
| Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps  15. a) Define a state and state transition matrix of the system.  4 2 5 1,2  b) Consider the system defined by $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u;$ $y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$  |            | $G(s) = \frac{K}{K}$   |   |   |   |     |
| Define a state and state transition matrix of the system.  Define a state and state transition matrix of the system. $ \begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u; $ $y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$   |            | s(s+1)(s+2)  |   |   |   | (d  |
| $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u;$ $y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$  |            | Draw a Nyquist (rough) plot of $G(s)$ with the detailed steps                                  |   |   |   |     |
| $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u;$ $y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$  | 15. a)     | Define a state and state transition matrix of the system.                                      | 4 | 2 | 5 | 1,2 |
| $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u;$ $y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$  | b)         | Consider the system defined by   | 4 | 3 | 5 | 1,2 |
| 1.731  |            | 033 2 0 11 03 3 2  |   |   |   |     |
| Is the system completely controllable and completely observable?   |            | $y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ |   |   |   |     |
|  |            | Is the system completely controllable and completely observable?                               |   |   |   |     |

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| 16. a) | For the Control System described by a Signal Flow Graph shown in below Figure, illustrate all the steps of Mason's Gain Formula and hence, determine the transfer function $\frac{x_7(s)}{x_1(s)}$ .   | 4 | 3 | 1 | 1,2 |
|--------|--|---|---|---|-----|
|        | $X_{1}$ $X_{2}$ $G_{2}(s)$ $X_{3}$ $G_{4}(s)$ $G_{5}(s)$ $G_{5}(s$ |   |   |   |     |
| b)     | Determine the values of damping factor, natural undamped frequency, damping frequency, percentage overshoot, peak time, rise time and settling time. $M(s) = \frac{49}{s^2 + 4s + 49}$   | 4 | 3 | 2 | 1,2 |
|        |  |   |   |   |     |
| 17.    | Answer any <i>two</i> of the following:  |   |   |   |     |
| a)     | Define Gain margin and phase margin. Compare the Lead compensator and Lag compensator.   | 4 | 1 | 3 | 1,2 |
| b)     | Sketch the polar plot of the following transfer functions  | 4 | 3 | 4 | 1,2 |
|        | a) $G(s) = \frac{1}{(1+sT_1)(1+sT_2)}$ b) $G(s) = \frac{1}{s^2(1+sT_1)(1+sT_2)}$   |   |   |   |     |
| c)     | Consider the following matrix A  | 4 | 3 | 5 | 1,  |
|        | $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$   |   |   |   |     |
|        | Compute $e^{At}$ .   |   |   |   |     |

M: Marks; L: Bloom's Taxonomy Level; CO; Course Outcome; PO: Programme Outcome

| i)   | Blooms Taxonomy Level – 1     | 21%   |
|------|-------------------------------|-------|
| ii)  | Blooms Taxonomy Level – 2     | 31.5% |
| (iii | Blooms Taxonomy Level – 3 & 4 | 47.5% |

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