# MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
*(A constituent unit of MAHE, Manipal)*

## COURSE PLAN

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|---|---|---|
| **Department** | : | Instrumentation & Control Engineering |
| **Course Name & code** | : | Modern Control Theory & 3153 |
| **Semester & branch** | : | V sem & E & I |
| **Name of the faculty** | : | Mr. Bipin Krishna & Mr. Mukund Kumar Menon |

**No of contact hours/week:**

| L | T | P | C |
|---|---|---|---|
| 3 | 1 | 0 | 4 |

### Course Outcomes (COs)

| | *At the end of this course, the student should be able to:* | No. of Contact Hours | Marks |
|---|---|---|---|
| CO1: | Understand the basic concept of state space analysis and apply to obtain the stae model in different forms. | 10 | 20 |
| CO2: | Analyze the stability, performance and apply state transformation technique. | 8 | 18 |
| CO3: | Design observer and state variable feedback control law. | 6 | 12 |
| CO4: | Understand different types of nonlinearities and analyse non linear system behaviour | 16 | 32 |
| CO5: | Analyse the stability of system using Lyaponuv Theory. | 8 | 18 |
| | **Total** | 48 | 100 |

## Assessment Plan

| Components | Assignments | Sessional Tests | End Semester/ Make-up Examination |
|---|---|---|---|
| **Duration** | 20 to 30 minutes | 60 minutes | 180 minutes |
| **Weightage** | 20 % (4 X 5 marks) | 30 % (2 X 15 Marks) | 50 % (1 X 50 Marks) |
| **Typology of Questions** | Understanding; Applying; Analyzing; Evaluating; Creating | Remembering; Understanding; Applying | Understanding; Applying; Analyzing; Evaluating; Creating |
| **Pattern** | Answer one randomly selected question from the problem sheet (Students can refer their class notes) | MCQ (10 marks): 10 questions of 0.5 marks each<br>Short Answers (10 marks): questions of 2 or 3 marks | Answer all 5 full questions of 10 marks each. Each question may have 2 to 3 parts of 3/4/5/6/7 marks |
| **Schedule** | As notified by Associate Director (Academics) at the start of each semester | Calendared activity | Calendared activity |
| **Topics Covered** | Assignment 1 ($L_{x1-x2}$ & $T_{y1-y2}$) **(CO x)** | Test 1 ($L_{a1-a2}$ & $T_{b1-b2}$) **(CO x)** | Comprehensive examination covering full syllabus. Students are expected to answer all questions **(CO1-5)** |
| | Assignment 2 ($L_{x3-x4}$ & $T_{y3-y4}$) **(CO x)** | | |
| | Assignment 3 ($L_{x5-x6}$ & $T_{y5-y6}$) **(CO x)** | Test 2 ($L_{a3-a4}$ & $T_{b3-b4}$) **(CO x)** | |
| | Assignment 4 ($L_{x7-x8}$ & $T_{y7-y8}$) **(CO x)** | | |

## Lesson Plan

| L. No. | Topics | Course Outcome Addressed |
|---|---|---|
| **L0** | Introduction to the course & Introduction to state concept. State space &Transfer function representation | CO1 |
| **L1** | State space modelling & analysis State equation of linear continuous data systems – Electrical System | CO1 |
| **L2** | State equation of linear continuous data systems – Mechanical System | CO1 |
| **L3** | State equation of linear continuous data systems – Electromechanical System | CO1 |
| **T1** | Tutorial/ Problem solving | CO1 |
| **L4** | State equation of linear continuous data systems – Electromechanical System | CO1 |
| **L5** | Phase variable form of state representation | CO1 |
| **L6** | Canonical form of state representation | CO2 |
| **T2** | Tutorial/ Problem solving | CO1 |

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| **L7** | Derivation of state models from ordinary differential equations | CO1 |
| **L8** | Direct, cascade, parallel realizations | CO1 |
| **L9** | Stability analysis | CO2 |
| **T3** | Tutorial/ Problem solving | CO2 |
| **L10** | Eigen values, Eigen vectors, sytem realisation : examples | CO2 |
| **L11** | Diagonalization | CO2 |
| **L12** | Transformation into canonical forms | CO2 |
| **T4** | Tutorial/ Problem solving | CO2 |
| **L13** | Solution of state equations | CO2 |
| **L14** | State transition matrix-Cayley Hamilton theorem | CO2 |
| **L15** | Controllability and observability: examples | CO3 |
| **T5** | Tutorial/ Problem solving | CO3 |
| **L16** | Pole placement –Ackerman's formula: Examples | CO3 |
| **L17** | State feedback and output feedback | CO3 |
| **L18** | Observer design | CO3 |
| **T6** | Tutorial/ Problem solving | CO3 |
| **L19** | Introduction to Nonlinear Systems, Characteristics of non- linear systems. | CO4 |
| **L20** | Linearization of NLS, Common type of nonlinearities. | CO4 |
| **L21** | Phase plane Analysis of NLS, Singular Points on Phase Plane. | CO4 |
| **L22** | Construction of the phase trajectory by Isocline's method | CO4 |
| **L23** | Pell's Method and Delta Method for constructing phase trajectories | CO4 |
| **T7** | Tutorial/ Example | CO4 |
| **L24** | Introduction to Describing function; Determination of describing function for various non linearities. | CO4 |
| **L25** | On-off, dead zone, on-off with dead zone. | CO4 |
| **L26** | Describing function of Saturation, Saturation With Dead Zone, Hysteresis, On-Off With Hysteresis | CO4 |
| **L27** | Examples | CO4 |
| **L28** | Linear Transfer Through Dead Zone, Square Nonlinearity, Cubic Nonlinearity | CO4 |
| **L29** | Examples | CO4 |
| **L30** | Application of describing function of stability analysis of systems with single nonlinearity | CO4 |

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| **L31** | Examples | CO4 |
| **T8** | Tutorial/Problems | CO4 |
| **L32** | Introduction to Lyapunov stability analysis- Technical terms used, Definitions of boundesness, stability, Asymptotic stability, Instability. | CO5 |
| **L33** | Sign definiteness of scalar functions. Sylvester's Criterion. | CO5 |
| **L34** | Examples | CO5 |
| **T9** | Tutorial/ Problem solving on stability analysis | CO5 |
| **L35** | Lyapunov Theorems of Stability, Instability and asymptotic stability, Illustrative examples on the application of Lyapunov second method | CO5 |
| **L36** | Examples | CO5 |
| **T10** | Tutorials | CO5 |
| **L37** | Recap of State concepts | CO |
| **L38** | Recap of nonlinear control | CO |
| **L/T** | Click or tap here to enter text. | |

**References:**


1. K. Ogata, "Modern control engineering", Prentice Hall India. 2002.
2. M. Gopal , "Modern control system theory", Wiley Eastern Limited 1984.
3. J.E.Gibson "Nonlinear automatic control ", McGraw Hill.1963.
4. Cunningham W.J. "Introduction to nonlinear analysis", McGraw Hill.1959.
5. K. Ogata "State space analysis of control systems" Prentice Hall India 1967.
6. A.Ramakalyan, "Control Engineering- A comprehensive foundation", Vikas Publishing House, New Delhi. 2004.
7. Click or tap here to enter text.


**Submitted by:** **BIPIN KRISHNA**

**(Signature of the faculty)**

**Date:** **25-07-2022**

**Approved by:** **DR. SHREESHA C.**

**(Signature of HOD)**

**Date:** **25-07-2022**

**FACULTY MEMBERS TEACHING THE COURSE (IF MULTIPLE SECTIONS EXIST):**

| FACULTY | SECTION | FACULTY | SECTION |
|---|---|---|---|
| Mr. Bipin Krishna | A | | |
| Mr. Mukund Kumar Menon | B | | |
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