

**COURSE:** Non CRS PATTERN

**Name of the Faculty:** Technology and Engineering

**Name of the Programme:** Master of Engineering- Electrical Engineering (Automatic Control & Robotics)

**Mode of Learning:** REGULAR

|                                                  |                                                                 |                                                                 |                                                                 |                |                                      |                                |                               |                            |          |          |             |                           |                                                              |
|--------------------------------------------------|-----------------------------------------------------------------|-----------------------------------------------------------------|-----------------------------------------------------------------|----------------|--------------------------------------|--------------------------------|-------------------------------|----------------------------|----------|----------|-------------|---------------------------|--------------------------------------------------------------|
| Semester Number (For Example 01,02,03, etc.):    |                                                                 |                                                                 |                                                                 |                | 01                                   |                                |                               |                            |          |          |             |                           |                                                              |
| Maximum Courses/Papers for the present Semester: |                                                                 |                                                                 |                                                                 |                | 07                                   |                                |                               |                            |          |          |             |                           |                                                              |
| Minimum Courses/Papers for the present Semester: |                                                                 |                                                                 |                                                                 |                | 07                                   |                                |                               |                            |          |          |             |                           |                                                              |
| Maximum marks for the present Semester:          |                                                                 |                                                                 |                                                                 |                | 550                                  |                                |                               |                            |          |          |             |                           |                                                              |
| Minimum marks for the present Semester:          |                                                                 |                                                                 |                                                                 |                | 00                                   |                                |                               |                            |          |          |             |                           |                                                              |
| Total Credits for the present Semester:          |                                                                 |                                                                 |                                                                 |                | NIL                                  |                                |                               |                            |          |          |             |                           |                                                              |
|                                                  |                                                                 |                                                                 |                                                                 |                |                                      |                                |                               |                            |          |          |             |                           |                                                              |
| Sr. No.                                          | Department (NAME OF THE DEPARTMENT WHICH IS TEACHING THE PAPER) | Type of Course Core/ Elective/ Foundation/ IDE/ Compulsory etc. | Title of Paper                                                  | Group (if any) | Hours of Teaching per week [Credit*] | Teaching Learning Method [TLM] | Assessment Method [AM]        | Assessment Type [AT] UA/IA | UA Marks | IA Marks | Total Marks | Minimum marks for Passing | Remarks for Minimum /Maximum Course/Paper/Subject/ Selection |
| 1                                                | Electrical Engineering                                          | Core Compulsory                                                 | Computer-Controlled Systems (ELE2138)                           | NA             | 04                                   | Lecture                        | Theory                        | UA                         | 70       | --       | 100         | 40                        | UA=70<br>IA=30                                               |
|                                                  |                                                                 |                                                                 |                                                                 |                |                                      |                                |                               | IA                         | --       | 30       |             |                           |                                                              |
| 2                                                | Electrical Engineering                                          | Core Compulsory                                                 | Computer-Controlled Systems (TW, Practical and Viva) (ELE2138L) | NA             | 03                                   | Laboratory                     | Term Work, Practical and Viva | UA                         | 50       | --       | 50          | 20                        | UA=50                                                        |
|                                                  |                                                                 |                                                                 |                                                                 |                |                                      |                                |                               | IA                         | --       | --       |             |                           |                                                              |
| 3                                                | Electrical Engineering                                          | Core Compulsory                                                 | Optimal & Robust Control (ELE2139)                              | NA             | 04                                   | Lecture                        | Theory                        | UA                         | 70       | --       | 100         | 40                        | UA=70<br>IA=30                                               |
|                                                  |                                                                 |                                                                 |                                                                 |                |                                      |                                |                               | IA                         | --       | 30       |             |                           |                                                              |
| 4                                                | Electrical Engineering                                          | Core Compulsory                                                 | Optimal & Robust Control (TW, Practical and Viva) (ELE2139L)    | NA             | 03                                   | Laboratory                     | Term Work, Practical and Viva | UA                         | 50       | --       | 50          | 20                        | UA=50                                                        |
|                                                  |                                                                 |                                                                 |                                                                 |                |                                      |                                |                               | IA                         | --       | --       |             |                           |                                                              |
| 5                                                | Electrical Engineering                                          | Core Compulsory                                                 | Applied Signal Processing & Filter Design (ELE2134)             | NA             | 04                                   | Lecture                        | Theory                        | UA                         | 70       | --       | 100         | 40                        | UA=70<br>IA=30                                               |
|                                                  |                                                                 |                                                                 |                                                                 |                |                                      |                                |                               | IA                         | --       | 30       |             |                           |                                                              |

|   |                        |                 |                                                                               |    |    |            |                               |    |    |    |     |    |                |
|---|------------------------|-----------------|-------------------------------------------------------------------------------|----|----|------------|-------------------------------|----|----|----|-----|----|----------------|
| 6 | Electrical Engineering | Core Compulsory | Applied Signal Processing & Filter Design (TW, Practical and Viva) (ELE2134L) | NA | 03 | Laboratory | Term Work, Practical and Viva | UA | 50 | -- | 50  | 20 | UA=50          |
|   |                        |                 |                                                                               |    |    |            |                               | IA | -- | -- |     |    |                |
| 7 | Electrical Engineering | Core Compulsory | Dynamical Systems Analysis (ELE2140)                                          | NA | 04 | Lecture    | Theory                        | UA | 70 | -- | 100 | 40 | UA=70<br>IA=30 |
|   |                        |                 |                                                                               |    |    |            |                               | IA | -- | 30 |     |    |                |

|                                                  |                                                                    |                                                                                   |                                                       |                |                                      |                                |                               |                                   |          |          |             |                           |                |
|--------------------------------------------------|--------------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------|----------------|--------------------------------------|--------------------------------|-------------------------------|-----------------------------------|----------|----------|-------------|---------------------------|----------------|
| Semester Number (For Example 01,02,03, etc.):    |                                                                    |                                                                                   |                                                       |                | 02                                   |                                |                               |                                   |          |          |             |                           |                |
| Maximum Courses/Papers for the present Semester: |                                                                    |                                                                                   |                                                       |                | 07                                   |                                |                               |                                   |          |          |             |                           |                |
| Minimum Courses/Papers for the present Semester: |                                                                    |                                                                                   |                                                       |                | 07                                   |                                |                               |                                   |          |          |             |                           |                |
| Maximum marks for the present Semester:          |                                                                    |                                                                                   |                                                       |                | 550                                  |                                |                               |                                   |          |          |             |                           |                |
| Minimum marks for the present Semester:          |                                                                    |                                                                                   |                                                       |                | 00                                   |                                |                               |                                   |          |          |             |                           |                |
| Total Credits for the present Semester:          |                                                                    |                                                                                   |                                                       |                | NIL                                  |                                |                               |                                   |          |          |             |                           |                |
|                                                  |                                                                    |                                                                                   |                                                       |                |                                      |                                |                               |                                   |          |          |             |                           |                |
| Sr. No.                                          | Department<br>(NAME OF THE DEPARTMENT WHICH IS TEACHING THE PAPER) | Type of Course<br>Core/<br>Elective/<br>Foundation/<br>IDE/<br>Compulsory<br>etc. | Title of Paper                                        | Group (if any) | Hours of Teaching per week [Credit*] | Teaching Learning Method [TLM] | Assessment Method [AM]        | Assessment Type [AT]<br>UA/<br>IA | UA Marks | IA Marks | Total Marks | Minimum marks for Passing | Remarks        |
| 1                                                | Electrical Engineering                                             | Core Compulsory                                                                   | Modern AI (ELE2239)                                   | NA             | 04                                   | Lecture                        | Theory                        | UA                                | 70       | --       | 100         | 40                        | UA=70<br>IA=30 |
|                                                  |                                                                    |                                                                                   |                                                       |                |                                      |                                |                               | IA                                | --       | 30       |             |                           |                |
| 2                                                | Electrical Engineering                                             | Core Compulsory                                                                   | Modern AI (TW, Practical and Viva) (ELE2239L)         | NA             | 03                                   | Laboratory                     | Term Work, Practical and Viva | UA                                | 50       | --       | 50          | 20                        | UA=50          |
|                                                  |                                                                    |                                                                                   |                                                       |                |                                      |                                |                               | IA                                | --       | --       |             |                           |                |
| 3                                                | Electrical Engineering                                             | Core Compulsory                                                                   | Machine Learning (ELE2240)                            | NA             | 04                                   | Lecture                        | Theory                        | UA                                | 70       | --       | 100         | 40                        | UA=70<br>IA=30 |
|                                                  |                                                                    |                                                                                   |                                                       |                |                                      |                                |                               | IA                                | --       | 30       |             |                           |                |
| 4                                                | Electrical Engineering                                             | Core Compulsory                                                                   | Machine Learning (TW, Practical and Viva) (ELE2240L)  | NA             | 03                                   | Laboratory                     | Term Work, Practical and Viva | UA                                | 50       | --       | 50          | 20                        | UA=50          |
|                                                  |                                                                    |                                                                                   |                                                       |                |                                      |                                |                               | IA                                | --       | --       |             |                           |                |
| 5                                                | Electrical Engineering                                             | Core Compulsory                                                                   | Embedded Applications in Industrial Control (ELE2235) | NA             | 04                                   | Lecture                        | Theory                        | UA                                | 70       | --       | 100         | 40                        | UA=70<br>IA=30 |
|                                                  |                                                                    |                                                                                   |                                                       |                |                                      |                                |                               | IA                                | --       | 30       |             |                           |                |

|   |                        |                 |                                                                                    |    |    |            |                               |    |    |    |     |    |                |
|---|------------------------|-----------------|------------------------------------------------------------------------------------|----|----|------------|-------------------------------|----|----|----|-----|----|----------------|
| 6 | Electrical Engineering | Core Compulsory | Embedded Applications in Industrial Control (TW, Practical and Viva)<br>(ELE2235L) | NA | 03 | Laboratory | Term Work, Practical and Viva | UA | 50 | -- | 50  | 20 | UA=50          |
|   |                        |                 |                                                                                    |    |    |            |                               | IA | -- | -- |     |    |                |
| 7 | Electrical Engineering | Core Compulsory | Adaptive Filtering & Control<br>(ELE2241)                                          | NA | 04 | Lecture    | Theory                        | UA | 70 | -- | 100 | 40 | UA=70<br>IA=30 |
|   |                        |                 |                                                                                    |    |    |            |                               | IA | -- | 30 |     |    |                |

|                                                  |                                                                    |                                                                                   |                           |                |                                      |                                |                        |                             |          |          |             |                           |         |  |
|--------------------------------------------------|--------------------------------------------------------------------|-----------------------------------------------------------------------------------|---------------------------|----------------|--------------------------------------|--------------------------------|------------------------|-----------------------------|----------|----------|-------------|---------------------------|---------|--|
| Semester Number (For Example 01,02,03, etc.):    |                                                                    |                                                                                   |                           |                | 03 & 04                              |                                |                        |                             |          |          |             |                           |         |  |
| Maximum Courses/Papers for the present Semester: |                                                                    |                                                                                   |                           |                | 01                                   |                                |                        |                             |          |          |             |                           |         |  |
| Minimum Courses/Papers for the present Semester: |                                                                    |                                                                                   |                           |                | 01                                   |                                |                        |                             |          |          |             |                           |         |  |
| Maximum marks for the present Semester:          |                                                                    |                                                                                   |                           |                | 300                                  |                                |                        |                             |          |          |             |                           |         |  |
| Minimum marks for the present Semester:          |                                                                    |                                                                                   |                           |                | 00                                   |                                |                        |                             |          |          |             |                           |         |  |
| Total Credits for the present Semester:          |                                                                    |                                                                                   |                           |                | NIL                                  |                                |                        |                             |          |          |             |                           |         |  |
|                                                  |                                                                    |                                                                                   |                           |                |                                      |                                |                        |                             |          |          |             |                           |         |  |
| Sr. No.                                          | Department<br>(NAME OF THE DEPARTMENT WHICH IS TEACHING THE PAPER) | Type of Course<br>Core/<br>Elective/<br>Foundation/<br>IDE/<br>Compulsory<br>etc. | Title of Paper            | Group (if any) | Hours of Teaching per week [Credit*] | Teaching Learning Method [TLM] | Assessment Method [AM] | Assessment Type [AT] UA/ IA | UA Marks | IA Marks | Total Marks | Minimum marks for Passing | Remarks |  |
| 1                                                | Electrical Engineering                                             | Core Compulsory                                                                   | ME Dissertation (ELE2401) | NA             |                                      | Project                        | Dissertation           | UA                          | 300      | --       | 300         | 120                       | UA=300  |  |
|                                                  |                                                                    |                                                                                   |                           |                |                                      |                                |                        | IA                          | --       | --       |             |                           |         |  |



**FACULTY OF TECHNOLOGY AND ENGINEERING**  
**THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA VADODARA**  
**Department of Electrical Engineering**  
**2 year Post Graduate Course**  
**ME ELECTRICAL (Automatic Control & Robotics)**

**Syllabus of Courses**

**M.E. Electrical (Automatic Control & Robotics) Part -I**

**Bloom's Taxonomy Levels:**

1. Remember    2. Understand    3. Application    4. Analysis    5. Evaluation    6. Creation

**Program Name: M.E (Electrical) Automatic Control & Robotics**

**Program Specific Outcomes (PSO)**

- PSO1- Student should obtain good command over the classical and modern control systems techniques and their applications to real-life problems in industries and society at large.
- PSO2-Student should develop ample insight into various AI and machine learning techniques and their implementation for real-life problems using prevalent software/hardware platforms.
- PSO3-Students should have adequate background to integrate advanced control systems ideas with AIML approaches implemented using software simulations or signal processing tools like digital processors or microcontrollers for creating innovative applications for societal needs and national priorities.
- PSO4-Student should be able to define and pursue a minor research problem based on literature review of quality journals and other resources.
- PSO5-Student should obtain good practice of oral and written communications through seminar presentations and report writing.
- PSO6- Student should develop an inclination for doing quality publication in reputed journals and be made aware of various indices for ranking the journals and individuals, also highlighting ethical issues related to publications.

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|  | <p style="text-align: center;"><b>FACULTY OF TECHNOLOGY AND ENGINEERING</b><br/> <b>THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA VADODARA</b><br/> <b>Department of Electrical Engineering</b><br/> <b>2 year Post Graduate Course</b><br/> <b>ME ELECTRICAL (Automatic Control &amp; Robotics)</b></p> |
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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---------------------------------|-----------------|-----------|------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                | <b>The Maharaja Sayajirao University of Baroda</b><br><b>Faculty Technology and Engineering</b><br><b>Department of Electrical Engineering</b> |                      | <b>Academic Year: 2021-2022</b> |                 |           |            |                                                                                        |                                                                      |                                                                                                                   |
| <b>Year</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>I</b>                                                       | <b>Core<br/>Computer-Controlled Systems</b>                                                                                                    |                      | <b>Credits / Hours per week</b> |                 |           |            | <b>04 + 03</b>                                                                         |                                                                      |                                                                                                                   |
| <b>Semester</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>I</b>                                                       | Year of Introduction: 2021<br>Year of Syllabus Revision: NIL                                                                                   |                      | <b>Maximum Marks / Grade</b>    |                 |           |            | <b>100 + 50</b>                                                                        |                                                                      |                                                                                                                   |
| <b>Course Outcomes (CO)</b><br><b>CO1:</b> Analyse the working of typical computer-based feedback control system in terms of its constituent parts.<br><b>CO2:</b> Obtain the mathematical model of system components based on operational principles and/or experimental results and therefrom model the overall computer controlled system.<br><b>CO3:</b> Given the mathematical model of a digital control system, determine performance specifications, and gauge the gap between required and actual performance.<br><b>CO4:</b> Given the mathematical model and required control specifications, design an appropriate compensator.<br><b>CO5:</b> Correlate various digital controller design approaches with different signal processing methods. |                                                                |                                                                                                                                                |                      |                                 |                 |           |            |                                                                                        |                                                                      |                                                                                                                   |
| <b>Mode of Transaction</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                | Lectures and Laboratory                                                                                                                        |                      |                                 |                 |           |            |                                                                                        |                                                                      |                                                                                                                   |
| <b>Unit No.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Topic</b>                                                   |                                                                                                                                                | <b>Contact Hours</b> | <b>Weightage (%)</b>            | <b>BT Level</b> | <b>CO</b> | <b>PSO</b> | <b>Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)</b> | <b>Relevance to Local (L)/ National (N)/ Regional (R)/Global (G)</b> | <b>Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV)and Professional Ethics (PE)</b> |
| 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Computer control theory. History and recent trends. Inherently |                                                                                                                                                | 08                   | 15                              | 2,3,4           | CO1       | PSO1       | SD                                                                                     | G                                                                    | ES, PE                                                                                                            |



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**ME ELECTRICAL (Automatic Control & Robotics)**

|   |                                                                                                                                                                                                                                                                                    |    |    |       |                   |                              |    |   |        |
|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|-------|-------------------|------------------------------|----|---|--------|
|   | sampled systems. Mathematical Background: Fourier Series and Fourier Transform. Laplace and Z transforms. Configuration of basic digital control system. Time domain models for discrete time systems. Transfer function and state-space models. Sampling, sampled spectra.        |    |    |       | CO5               | PSO3<br>PSO5                 |    |   |        |
| 2 | Principles of discretization. Stability of discrete-time systems. Sensitivity and robustness. Controllability, Reachability, Observability and Detectability. Analysis of basic feedback loops. Practical aspects of sampling rate selection.                                      | 08 | 15 | 3,5,6 | CO1<br>CO2<br>CO3 | PSO1<br>PSO3<br>PSO5         | SD | G | ES, PE |
| 3 | Z-domain description of sampled-data systems. Implementation of Digital controllers: Prefiltering and computational delay, nonlinear actuators, operational aspects, numerics, realizations digital controllers and programming. Digital PID controllers.                          | 09 | 15 | 3.5.6 | CO2<br>CO3        | PSO1<br>PSO3<br>PSO5         | SD | G | ES, PE |
| 4 | Design of Digital controllers: z-plane specifications for control system design – stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness. Digital compensator design using iterative and direct synthesis approaches.           | 10 | 20 | 4,5.6 | CO3<br>CO4<br>CO5 | PSO1<br>PSO3<br>PSO5<br>PSO6 | SD | G | ES, PE |
| 5 | Pole Placement Design: Regulation by state feedback. Design of state observers and compensator design by separation principle. Output feedback and servo problem. Deadbeat control by state feedback and deadbeat observers. Diophantine equation. Sensitivity to modeling errors. | 09 | 20 | 4,5,6 | CO3<br>CO4        | PSO1<br>PSO3<br>PSO5<br>PSO6 | SD | G | ES, PE |
| 6 | Lyapunov functions for linear and nonlinear systems. LQ, LQG and Minimum Variance control. Variable Structure, Sliding Mode and Reinforcement Learning control. Introduction to system identification.                                                                             | 08 | 15 | 4,5,6 | CO3<br>CO4        | PSO1<br>PSO3<br>PSO5<br>PSO6 | SD | G | ES, PE |

**Remarks:** Above theory syllabus entails 10 to 12 lab exercises

**References :**

|    |                                                                                                              |
|----|--------------------------------------------------------------------------------------------------------------|
| 1. | 'Digital Control and State Variable Methods', by M. Gopal, 4 <sup>th</sup> ed., McGraw Hill Education (2017) |
| 2. | Astrom & Wittenmark: 'Computer-controlled systems', Tata Mc Graw Hill                                        |
| 3. | 'Discrete-time control systems', by K Ogata, 2nd ed., Pearson Education, (2015)                              |
| 4. | B C Kuo: Digital Control System, PHI                                                                         |
| 5. | Franklin & Powell: 'Digital Control of dynamic systems, Tata McGraw Hill                                     |

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|-------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>सत्यं शिवं सुन्दरम्</p> | <p align="center"><b>FACULTY OF TECHNOLOGY AND ENGINEERING</b><br/> <b>THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA VADODARA</b><br/> <b>Department of Electrical Engineering</b><br/> <b>2 year Post Graduate Course</b><br/> <b>ME ELECTRICAL (Automatic Control &amp; Robotics)</b></p> |
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| <br>सत्यं शिवं सुन्दरम्                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | The Maharaja Sayajirao University of Baroda<br>Faculty Technology and Engineering<br>Department of Electrical Engineering |                                                                       | Academic Year            |               |          |    | 2021-22                        |                                                                         |                                                               |                                                                                                            |
| ME (E) (ACR): Regular Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                           |                                                                       |                          |               |          |    |                                |                                                                         |                                                               |                                                                                                            |
| Year                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | I                                                                                                                         | Core / <del>Elective</del> / Foundation<br>Optimal and Robust Control | Credits / Hours per week |               |          |    | L: 4 hrs/week<br>Pr: 3hrs/week |                                                                         |                                                               |                                                                                                            |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | I                                                                                                                         | Year of Introduction: 2021<br>Year of Syllabus Revision: NIL          | Maximum Marks / Grade    |               |          |    | 100+50                         |                                                                         |                                                               |                                                                                                            |
| Mode of Transaction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                           | Lectures and Laboratory                                               |                          |               |          |    |                                |                                                                         |                                                               |                                                                                                            |
| <b>Course Outcome (CO)</b><br>CO1: Explain principles and fundamental concepts of Optimal control systems, its representations and various performance measures<br>CO2:Analyse the optimal control system in view of Variational calculus problemsand its variants<br>CO3: Apply Linear programming techniques and analyse them for sensitivity<br>CO4: Explain basic concepts of Robust control system, its representation and applications<br>CO5 explain the concept of uncertainties that exists in the various systems and its solutions<br>CO6: Analyse and design controllers to make systems robust |                                                                                                                           |                                                                       |                          |               |          |    |                                |                                                                         |                                                               |                                                                                                            |
| Unit No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Topic                                                                                                                     |                                                                       | Contact Hours            | Weightage (%) | BT Level | CO | PSO                            | Element s of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Develop | Relevance to Local (L)/ National (N)/ Regional (R)/Global (G) | Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV)and Professional Ethics (PE) |



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|   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |    |    |         |            |                      | ment<br>(SD) |          |           |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|---------|------------|----------------------|--------------|----------|-----------|
| 1 | Optimization Methods: Variational Calculus: Euler Lagrange Equation, Free and Fixed End point problems, Problems with constraints and discontinuity. Pontryagin's Maximum Principle                                                                                                                                                                                                                                                                                                              | 09 | 20 | 2,3,4   | CO2<br>CO1 | PSO1<br>PSO2         | <b>SD</b>    | <b>G</b> | <b>PE</b> |
| 2 | System Optimization: Formulation of Bolza, Mayer and Lagrange problems for Discrete and Continuous time systems using various optimization methods. Bang Bang control, Minimum time control. Convex Optimization: Notations, Problems, algorithms such as: Cutting Plans, Elliptical etc. Complexity in Optimization.                                                                                                                                                                            | 08 | 15 | 1,2,3,4 | CO2<br>CO1 | PSO1<br>PSO3<br>PSO5 |              |          |           |
| 3 | Linear Programming, Modeling with Linear Programming Geometry of Linear Programming Problems Selected LP applications; Simplex method and Sensitivity analysis, Solution of a System of Linear Simultaneous Equations, Pivotal Reduction of a General System of Equations, Simplex Algorithm, Identifying an Optimal Point, Improving a Nonoptimal Basic Feasible Solution, Two Phases of the Simplex Method and sensitivity analysis                                                            | 08 | 15 | 2, 3,4  | CO3        | PSO1<br>PSO4         |              |          |           |
| 4 | Introduction to Basic Concepts of Robust control; Stability of LTI Systems, Linear Fractional Transformations, Stabilizing Controllers for System Interconnection; A Specific Tracking Interconnection, The General Framework, Stabilizing Controllers - State-Space Descriptions, Stabilizing Controllers - Input-Output Descriptions, Generalized Plants, Robust Stability Analysis, Uncertainties in the Tracking Configuration – Examples                                                    | 09 | 10 | 1,2,3,4 | CO4        | PSO1<br>PSO3         |              |          |           |
| 5 | A Classical SISO Example, A Modern MIMO Example, Types of Uncertainties of System Components, Parametric Uncertainties, Dynamic Uncertainties, Mixed Uncertainties, Unstructured Uncertainties, Unstructured versus Structured Uncertainties, Pulling Uncertainties out of Subsystems, Pulling Uncertainties out of Interconnections, Robust Performance Analysis, Problem Formulation, Testing Robust Performance, The Main Loop Theorem, The Main Robust Stability and Robust Performance Test | 09 | 20 | 2,3,4   | CO5        | PSO1<br>PSO3<br>PSO5 |              |          |           |
| 6 | Synthesis of $H_\infty$ Controllers, The Algebraic Riccati Equation and                                                                                                                                                                                                                                                                                                                                                                                                                          | 09 | 20 | 1,2,3,4 | CO6        | PSO1                 |              |          |           |



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**ME ELECTRICAL (Automatic Control & Robotics)**

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| Inequality, Computation of $H_\infty$ Norms, The Bounded Real Lemma, The $H_\infty$ -Control Problem, $H_\infty$ -Control for a Simplified Generalized Plant Description, The State-Feedback Problem, Solution in Terms of Riccati Inequalities, Solution in Terms of Riccati Equations, $H_\infty$ -Control by Output-Feedback, Solution in Terms of Riccati Inequalities, Solution in Terms of Riccati Equations, Solution in Terms of Indefinite Riccati Equations, Weakest Hypotheses for the Riccati Solution, Case Study for Robust Algorithms |                                                                                                                 |  |  |  |  | PSO3<br>PSO5 |  |  |  |
| <b>Reference Books</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                 |  |  |  |  |              |  |  |  |
| 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Optimal Control Theory: An Introduction, Donald E. Kirk, Prentice-Hall, 1970                                    |  |  |  |  |              |  |  |  |
| 2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Optimum Systems Control, Andrew P. Sage, Prentice-Hall, 1968                                                    |  |  |  |  |              |  |  |  |
| 3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Engineering Optimization – Theory and Practice– Singiresu S Rao, - 4th Edition- 2009 by John Wiley & Sons, Inc. |  |  |  |  |              |  |  |  |
| 4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Essentials of Robust Control by KeminZhou, JohnC. Doyle                                                         |  |  |  |  |              |  |  |  |
| 5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Robust Adaptive Control – P A Ioannou& Jing Sun                                                                 |  |  |  |  |              |  |  |  |
| 6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | A course in robust control by DullerudG.,PaganiniF.                                                             |  |  |  |  |              |  |  |  |
| 7.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Theory of Robust Control by Carsten Scherer                                                                     |  |  |  |  |              |  |  |  |

Laboratory : 8-12 Experiments/Simulations based on syllabus contents.

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|  <p>सत्यं शिवं सुन्दरम्</p> | <p align="center"><b>FACULTY OF TECHNOLOGY AND ENGINEERING</b><br/> <b>THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA VADODARA</b><br/> <b>Department of Electrical Engineering</b><br/> <b>2 year Post Graduate Course</b><br/> <b>ME ELECTRICAL (Automatic Control &amp; Robotics)</b></p> |
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|  <p>सत्यं शिवं सुन्दरम्</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <p><b>The Maharaja Sayajirao University of Baroda</b><br/> <b>Faculty Technology and Engineering</b><br/> <b>Department of Electrical Engineering</b></p> | <p>Academic Year</p>                                                                           | <p>2021-22</p>                                                                                                                                                                                                                                                                                   |
| <b>ME (E) (ACR): Regular Programme</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                           |                                                                                                |                                                                                                                                                                                                                                                                                                  |
| <b>Year</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>I</b>                                                                                                                                                  | <b>Core / <del>Elective</del> / Foundation<br/>Applied Signal Processing and Filter Design</b> | <b>L: 4 hrs/week<br/>Pr: 3hrs/week</b>                                                                                                                                                                                                                                                           |
| <b>Semester</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>I</b>                                                                                                                                                  | Year of Introduction: 2021<br>Year of Syllabus Revision: NIL                                   | <b>Maximum Marks / Grade</b>                                                                                                                                                                                                                                                                     |
| <b>Mode of Transaction</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                           | Lectures and Laboratory                                                                        |                                                                                                                                                                                                                                                                                                  |
| <p><b>Course Outcome (CO)</b><br/> CO1: Illustrate applied aspects of various algorithms of transforming discrete time signal from time domain to frequency domain and vice versa.<br/> CO2: Implement different type of discrete time systems/filters in view of their various characteristics.<br/> CO3: Design discrete time filters for various applications.<br/> CO4: Describe multirate signal processing, its implementation in terms of various filter banks, techniques of sampling rate conversion in time domain and frequency domain<br/> CO5: Apply concepts of multirate sampling and adaptive filtering for text, speech, audio and image transformation, coding and compression.<br/> CO6: Illustrate various power spectrum techniques.</p> |                                                                                                                                                           |                                                                                                |                                                                                                                                                                                                                                                                                                  |
| <b>Unit No.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Topic</b>                                                                                                                                              | <b>Contact Hours</b>                                                                           | <b>Weightage (%)</b><br><b>BT Level</b><br><b>CO</b><br><b>PSO</b><br><b>Elements of Employability (Emp)/ Entrepreneurship</b><br><b>Relevance to Local (L)/ National (N)/ Regional (R)/ Global</b><br><b>Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and</b> |



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|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|-------------|-------------------|------------------------------|--------------------------------------------|----------|-----------------------------|
| 1 | Discrete Fourier Transform: redundancy in DFT, The inverse transform, Circular convolution, Filtering of long data sequence, sectioned convolution, Twiddle factor, Fast Fourier transform FFT Algorithms for convolution & correlations                                                                                                                                                             | 09 | 17 | 1,2,3       | CO1<br>CO2        | PSO1<br>PSO2<br>PSO3<br>PSO4 | <b>SD</b>                                  | <b>G</b> | <b>PE</b>                   |
| 2 | Structures for Discrete Time Systems; Structures of filters : Direct Form 1 & 2, Parallel, Cascade, Canonic realizations, Lattice structures; Fixed-Point & Binary Floating-point Representation of numbers, Errors Resulting from Rounding and Truncation, Analysis of Finite word length effects, Quantization effects on Filter Coefficients in FIR Filters, Round-Off Effects in Digital Filters | 07 | 08 | 1,2,4       | CO1<br>CO2        | PSO1<br>PSO2<br>PSO3<br>PSO4 |                                            |          |                             |
| 3 | Filter Design Procedures: Design of IIR& FIR filters. IIR design techniques; via analog conversion, Butterworth, Chebyshev, Bessel's filters. A generalized design procedure for IIR filters. FIR designs via Ideal low pass filters, Time domain window functions. Low pass FIR filter design procedure.                                                                                            | 11 | 25 | 2,4,3,<br>5 | CO2<br>CO1<br>CO3 | PSO1<br>PSO2<br>PSO3<br>PSO4 |                                            |          |                             |
| 4 | Multirate digital signal processing: interpolator, Decimator, multistage implementation of sampling rate conversion, sampling rate conversion by an arbitrary factor                                                                                                                                                                                                                                 | 06 | 08 | 1,2,4       | CO4               | PSO1<br>PSO2<br>PSO3<br>PSO4 |                                            |          |                             |
| 5 | Applications of multi rate signal processing, multirate filter banks and subband coding, digital speech coding, speech signal analysis and Transform coding, Hilbert Transform, Haar transform, Wavelet transform; Adaptive filtering, Minimum mean square criterion, Wiener filter, LMS adaptive algorithm                                                                                          | 10 | 24 | 2,3,4       | CO5<br>CO4        | PSO1<br>PSO2<br>PSO3<br>PSO4 |                                            |          |                             |
| 6 | Power spectrum estimation, Estimation of Spectra from Finite-duration Observations of signals Estimation of the Autocorrelation and Power spectrum estimation of Random Signals, The Periodogram, Use of DFT in power spectrum estimation. Parametric methods of power spectrum estimation, Eigen analysis Algorithms for Spectrum estimation- MUSIC, ESPRIT algorithm                               | 09 | 18 | 2,3,4       | CO6               | PSO1<br>PSO2<br>PSO3<br>PSO4 |                                            |          |                             |



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**Reference Books**

|    |                                                                                                                                     |
|----|-------------------------------------------------------------------------------------------------------------------------------------|
| 1. | Digital Signal Processing: Principles, Algorithms and Applications: John G. Proakis and Dimitris G. Manolakis (Prentice Hall India) |
| 2. | Digital Signal Processing: A Computer Based approach: Sanjit K. Mitra (Tata McGraw Hill)                                            |
| 3. | Digital Signal Processing – A practical Approach: Emmanuel Ifeachor and Barry Jervis, Addison Wesley publishing company             |
| 4. | Digital Signal Processing Using MATLAB & Wavelets, Michael Weeks, 2 <sup>nd</sup> edition, INFINITY SCIENCE PRESS                   |
| 5. | Discrete-Time Signal Processing: A.V. Oppenheim and R.S. Schaffer (Prentice Hall India)                                             |
| 6. | Digital Signal Processing Using MATLAB Vinay K. Ingle, John G. Proakis, 3rd Edition, 2012, Cengage learning                         |

Laboratory :6-10 Experiments/Simulations based on syllabus contents.

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| <br>सत्यं शिवं सुन्दरम्                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |       | The Maharaja Sayajirao University of Baroda<br>Faculty Technology and Engineering<br>Department of Electrical Engineering |  | Academic Year: 2021-2022 |               |          |    |     |                                                                            |                                                               |                                                                                                             |
| Year                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | I     | Core<br>Dynamical Systems Analysis                                                                                        |  | Credits / Hours per week |               |          |    | 04  |                                                                            |                                                               |                                                                                                             |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | I     | Year of Introduction: 2021<br>Year of Syllabus Revision: NIL                                                              |  | Maximum Marks / Grade    |               |          |    | 100 |                                                                            |                                                               |                                                                                                             |
| Course Outcomes (CO)<br>CO 1: Utilize notions of basic linear algebra to model control systems.<br>CO 2: Analyze the performance of a control system, given its state-space model.<br>CO 3: Analyze and correlate the performance analysis of control system using input-output maps and state-space models.<br>CO 4: Evaluate the state feedback and optimization aspects for a given control application based on modeling.<br>CO 5: Analyze the performance of typical nonlinear systems correlating with robustness and optimization aspects.<br>CO 6: Correlated the nonlinear systems analysis with the notions of chaos and fractals. |       |                                                                                                                           |  |                          |               |          |    |     |                                                                            |                                                               |                                                                                                             |
| Mode of Transaction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |       | Lectures                                                                                                                  |  |                          |               |          |    |     |                                                                            |                                                               |                                                                                                             |
| Unit No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Topic |                                                                                                                           |  | Contact Hours            | Weightage (%) | BT Level | CO | PSO | Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development | Relevance to Local (L)/ National (N)/ Regional (R)/Global (G) | Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE) |



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|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|-------|-------------------|------------------------------|------|---|--------|
| 1 | Linear vector spaces, linear transformations, and matrices. Scalar products and norms. Eigenvalues, Eigenvectors, and canonical forms. State equations and state diagrams for continuous-time and discrete-time systems.                                                                                                                                                                             | 06 | 10 | 2,3,4 | CO1<br>CO2        | PSO1<br>PSO3<br>PSO5         | SD   | G | ES, PE |
| 2 | State assignment for linear and nonlinear systems. Local linearization of nonlinear systems. Solution of linear/nonlinear, continuous-time/discrete-time, time-invariant/time-varying state equations. Controllability and observability of linear/nonlinear, continuous-time/discrete-time, time-invariant/time-varying systems. Controllability and Reachability, Observability and Detectability. | 10 | 20 | 3,5,6 | CO1<br>CO2<br>CO3 | PSO1<br>PSO3<br>PSO5         | SD   | G | ES, PE |
| 3 | Interrelationships of input/output maps and state models. Output controllability, deadbeat controller, reducibility. Lyapunov and BIBO stability. Direct method of Lyapunov for linear/nonlinear, continuous-time/discrete-time systems. Invariance principle and Region of attraction. Converse Lyapunov Theorems.                                                                                  | 10 | 20 | 3.5.6 | CO2<br>CO3<br>CO5 | PSO1<br>PSO3<br>PSO5         | SD   | G | ES, PE |
| 4 | Parameter optimization and optimal state regulator. Constrained state feedback. Lyapunov functions, Lyapunov linearization and local stability. Feedback linearization. Elements of reinforcement learning and dynamic programming.                                                                                                                                                                  | 08 | 15 | 4,5,6 | CO3<br>CO4<br>CO5 | PSO1<br>PSO3<br>PSO5<br>PSO6 | SD   | G | ES, PE |
| 5 | Describing function analysis of common nonlinearities. Multiple equilibria and limit cycles. Phase plane analysis and phase portraits. Variable structure system and sliding mode control. Sliding modes and sliding surface design. Sliding modes in solving optimization problems.                                                                                                                 | 12 | 25 | 4,5,6 | CO3<br>CO5<br>CO6 | PSO1<br>PSO3<br>PSO5<br>PSO6 | SD   | G | ES, PE |
| 6 | Chaotic systems and fractals. Logistic equation and logistic map. Lyapunov exponents. Discretization chaos. Controlling chaotic systems.                                                                                                                                                                                                                                                             | 06 | 10 | 4,5,6 | CO3<br>CO5<br>CO6 | PSO1<br>PSO3<br>PSO5<br>PSO6 | SD   | G | ES, PE |

**References:**

|    |                                                                                                             |
|----|-------------------------------------------------------------------------------------------------------------|
| 1. | 'Modern Control System Theory', by MGopal, 3 <sup>rd</sup> ed., New Age publishers                          |
| 2. | 'Digital Control and State Variable Methods', by M Gopal, 4 <sup>th</sup> ed., McGraw Hill Education (2017) |
| 3. | 'Systems and Control', by Stanislav Zak, Oxford                                                             |



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| 4. | 'Nonlinear Control', by Hassan Khalil, Pearson Education (2015) |
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## Syllabus of Courses

### M.E. Electrical (Automatic Control & Robotics) Part -II

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                             |                                                                                                                                                |                               |                                 |                 |           |                 |                                                                                        |                                                                       |                                                                                                                    |
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| <br>सत्यं शिवं सुन्दरम्                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                             | <b>The Maharaja Sayajirao University of Baroda</b><br><b>Faculty Technology and Engineering</b><br><b>Department of Electrical Engineering</b> |                               | <b>Academic Year: 2021-2022</b> |                 |           |                 |                                                                                        |                                                                       |                                                                                                                    |
| <b>Year</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>I</b>                    | <b>Core Modern AI</b>                                                                                                                          | <b>Credits Hours per week</b> |                                 |                 |           | <b>04 + 03</b>  |                                                                                        |                                                                       |                                                                                                                    |
| <b>Semester</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>II</b>                   | Year of Introduction: 2021<br>Year of Syllabus Revision: NIL                                                                                   | <b>Maximum Marks</b>          |                                 |                 |           | <b>100 + 50</b> |                                                                                        |                                                                       |                                                                                                                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Mode of Transactions</b> | Lecture and Laboratory                                                                                                                         |                               |                                 |                 |           |                 |                                                                                        |                                                                       |                                                                                                                    |
| <b>Course Outcomes (CO)</b><br><b>CO1:</b> Appraise evolution of modern AI at the intersections of multiple disciplines like mathematics, logic, computer science, robotics, cybernetics, cognitive science, linguistics etc.<br><b>CO2:</b> Analyze given AI agent based on level of intelligence, task environment and its properties.<br><b>CO3:</b> Propose suitable AIML approach for a practical application based on comparative idea of strengths and weaknesses of different methods.<br><b>CO4:</b> Suggest formulation of a practical issue as problem-solving or knowledge-based agent.<br><b>CO5:</b> Analyze an AI application for uncertainty and potential for learning.<br><b>CO6:</b> Correlate machine learning ideas with GA and modern agent-based AI for an application. |                             |                                                                                                                                                |                               |                                 |                 |           |                 |                                                                                        |                                                                       |                                                                                                                    |
| <b>Mode of Transaction</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                             | Lectures and Laboratory                                                                                                                        |                               |                                 |                 |           |                 |                                                                                        |                                                                       |                                                                                                                    |
| <b>Unit No.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Topic</b>                |                                                                                                                                                | <b>Contact Hours</b>          | <b>Weightage (%)</b>            | <b>BT Level</b> | <b>CO</b> | <b>PSO</b>      | <b>Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)</b> | <b>Relevance to Local (L)/ National (N)/ Regional (R)/ Global (G)</b> | <b>Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)</b> |



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|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|-------|-------------------|----------------------|-----------------|---|--------|
| 1 | Introduction to modern AI: Definitions, historical perspectives, and multidisciplinary aspects. Turing Test and rational agent approaches. PEAS descriptions and properties of task environments. Classification of basic agent types: simple reflex, model-based, goal-based, utility-based and learning agents. | 06 | 10 | 3,4   | CO1<br>CO2        | PSO2<br>PSO3         | Emp,<br>Ent, SD | G | ES, PE |
| 2 | Problem-Solving agents. Uninformed (blind) and Informed (heuristic) search strategies. Local search and optimization problems. Online search agents. Adversarial search and games. Constraint satisfaction problems.                                                                                              | 10 | 20 | 4,5,6 | CO2<br>CO3<br>CO4 | PSO2<br>PSO3<br>PSO5 | Emp,<br>Ent, SD | G | ES, PE |
| 3 | Knowledge-based agents. Agents based on propositional logic. Knowledge engineering in first-order logic. Inference in first-order logic. Classical planning. Planning and acting in the real world. Knowledge representation.                                                                                     | 10 | 20 | 4,5,6 | CO2<br>CO3<br>CO4 | PSO2<br>PSO5         | Emp,<br>Ent, SD | G | ES, PE |
| 4 | Acting under uncertainty. Approximate reasoning in Bayesian networks. Relational and first-order probability models. Hidden Markov models and Kalman filters. Learning from examples. Knowledge-based learning. Statistical learning. Passive and active reinforcement learning.                                  | 08 | 15 | 4,5,6 | CO2<br>CO3<br>CO5 | PSO2<br>PSO3<br>PSO5 | Emp,<br>Ent, SD | G | ES, PE |
| 5 | Evolutionary Computation (EC). Elements of Canonical Genetic Algorithms [CGA] and their relationships with traditional search and optimization methods. Applications of GA to control, optimization and AI problems. Swarm Intelligence: PSO, ABC, ACO etc.                                                       | 10 | 20 | 4,5   | CO4<br>CO5        | PSO2<br>PSO5         | Emp,<br>Ent, SD | G | ES, PE |
| 6 | Robotics: Robot hardware. Robotic perception and machine vision. Planning movements. Robotic software architectures.                                                                                                                                                                                              | 08 | 15 | 4,6   | CO3<br>CO6        | PSO2<br>PSO3<br>PSO5 | Emp,<br>Ent, SD | G | ES, PE |

**Remarks:** Above theory syllabus entails 10 to 12 lab exercises (39 hrs)

**References:**

|    |                                                                                                                    |
|----|--------------------------------------------------------------------------------------------------------------------|
| 1. | Artificial Intelligence: A Modern Approach 3 <sup>rd</sup> ed., by Stuart Russel & Peter Norvig, Pearson Education |
| 2. | David E. Goldberg :Genetic Algorithms :Theory, Hardware, Software, Addison Wesley (1989)                           |
| 3. | Melanie Mitchell. :An introduction to Genetic Algorithms , PHI                                                     |
| 4. | ‘Robotics – control, sensing, vision and intelligence’, by K S Fu, Gonzalez and Lee, McGraw Hill Education (2017)  |
| 5. | ‘Neural Networks and Learning Machines’ 3 <sup>rd</sup> ed., Simon Haykin, Pearson                                 |
| 6. | AI for Engineers, by Robert Schalkoff, McGraw Hill                                                                 |

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                 | <b>The Maharaja Sayajirao University of Baroda</b><br><b>Faculty Technology and Engineering</b><br><b>Department of Electrical Engineering</b> |                               | <b>Academic Year: 2021-2022</b> |                 |                   |                      |                                                                                         |                                                                       |                                                                                                                    |
| <b>Year</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>I</b>                                                                                                                                                                        | <b>Core Machine Learning</b>                                                                                                                   | <b>Credits Hours per week</b> |                                 |                 | <b>04 + 03</b>    |                      |                                                                                         |                                                                       |                                                                                                                    |
| <b>Semester</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>II</b>                                                                                                                                                                       | Year of Introduction: 2021<br>Year of Syllabus Revision: NIL                                                                                   | <b>Maximum Marks</b>          |                                 |                 | <b>100 + 50</b>   |                      |                                                                                         |                                                                       |                                                                                                                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Mode of Transactions</b>                                                                                                                                                     | Lectures and Laboratory                                                                                                                        |                               |                                 |                 |                   |                      |                                                                                         |                                                                       |                                                                                                                    |
| <b>Course Outcomes (CO)</b><br><b>CO1:</b> Classify various soft computing and machine learning methods based on relative strengths and limitations.<br><b>CO2:</b> Evaluate an ANN approach for suitability for given application.<br><b>CO3:</b> Propose suitable AIML approach for a practical application based on comparative idea of strengths and weaknesses of different methods.<br><b>CO4:</b> Determine appropriate fuzzy logic control structure for given application.<br><b>CO5:</b> Analyze an AI application for uncertainty and potential for learning.<br><b>CO6:</b> Correlate machine learning ideas with GA, modern agent-based AI and control for an application. |                                                                                                                                                                                 |                                                                                                                                                |                               |                                 |                 |                   |                      |                                                                                         |                                                                       |                                                                                                                    |
| <b>Unit No.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Topic</b>                                                                                                                                                                    |                                                                                                                                                | <b>Contact Hours</b>          | <b>Weightage (%)</b>            | <b>BT Level</b> | <b>CO</b>         | <b>PSO</b>           | <b>Element s of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)</b> | <b>Relevance to Local (L)/ National (N)/ Regional (R)/ Global (G)</b> | <b>Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)</b> |
| 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Fuzzy sets, Fuzzy numbers, Fuzzy relations, and Fuzzy logic. Defuzzification, Fuzzy systems and modeling of static and dynamic fuzzy systems.                                   |                                                                                                                                                | 06                            | 10                              | 3,4             | CO1<br>CO4        | PSO2<br>PSO3         | Emp, Ent, SD                                                                            | G                                                                     | ES, PE                                                                                                             |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Fuzzy inference and Mamdani and Sugeno architectures. Fuzzy control and fuzzy control system design. Fuzzy knowledge-based control and fusion of fuzzy with PID. Adaptive fuzzy |                                                                                                                                                | 10                            | 20                              | 4,5,6           | CO3<br>CO4<br>CO6 | PSO2<br>PSO3<br>PSO5 | Emp, Ent, SD                                                                            | G                                                                     | ES, PE                                                                                                             |

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|  <p>सत्यं शिवं सुन्दरम्</p> | <p align="center"><b>FACULTY OF TECHNOLOGY AND ENGINEERING</b><br/> <b>THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA VADODARA</b><br/> <b>Department of Electrical Engineering</b><br/> <b>2 year Post Graduate Course</b><br/> <b>ME ELECTRICAL (Automatic Control &amp; Robotics)</b></p> |
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|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|-------|--------------------------|----------------------|-----------------|---|--------|
|   | control and nonlinear fuzzy control.                                                                                                                                                                                                                                                                                      |    |    |       |                          |                      |                 |   |        |
| 3 | Human brain and Neural Network architectures. Perceptron and its relation with Bayes classifier. Model building through regression. LMS algorithm and statistical LMS learning theory.                                                                                                                                    | 08 | 20 | 4,5,6 | CO1<br>CO2               | PSO2<br>PSO5         | Emp,<br>Ent, SD | G | ES, PE |
| 4 | Forms of learning and supervised learning. Learning decision trees and choosing best hypothesis. Theory of learning. Regression and classification with linear models. ANNs and nonparametric models. Support Vector machines and ensemble averaging. Explanation based learning and learning using relevant information. | 10 | 15 | 4,5,6 | CO1<br>CO2<br>CO5        | PSO2<br>PSO3<br>PSO5 | Emp,<br>Ent, SD | G | ES, PE |
| 5 | Multilayer Perceptron and Back Propagation Algorithm. Supervised learning as an optimization problem. Kernel methods and Radial Basis Function (RBF) Networks. Hybrid learning procedure for RBF networks. System identification and control using ANNs.                                                                  | 10 | 20 | 4,5   | CO1<br>CO2<br>CO5<br>CO6 | PSO2<br>PSO5         | Emp,<br>Ent, SD | G | ES, PE |
| 6 | Design of Support Vector Machines. Principles of self-organization. Kernel Principal Component Analysis and Kernel Hebbian Algorithm. Self-organizing map and Kernel self-organizing map.                                                                                                                                 | 08 | 15 | 4,6   | CO1<br>CO2<br>CO5<br>CO6 | PSO2<br>PSO3<br>PSO5 | Emp,<br>Ent, SD | G | ES, PE |

**Remarks:** Above theory syllabus entails 10 to 12 lab exercises (39 hrs)

**References:**

|    |                                                                                                              |
|----|--------------------------------------------------------------------------------------------------------------|
| 1. | 'Neural Networks and Learning Machines' 3 <sup>rd</sup> ed., Simon Haykin, Pearson                           |
| 2. | 'Fuzzy Logic Models and Fuzzy Control', D S Hooda & Vivek Raich, Alpha Science                               |
| 3. | 'Artificial Intelligence – A Modern Approach', 3 <sup>rd</sup> ed., by Stuart Russel & Peter Norvig, Pearson |
| 4. | RKrusse, JGebhart & F Klawonn : Foundation of Fuzzy Systems, John Wiley & Sons.                              |
| 5. | Bart Kosko: Neural Network & Fuzzy Systems, Prentice Hall [India]                                            |
| 6. | Jacob Zurada: Introduction to Neural Networks, Jaico Publishers.                                             |
| 7. | 'Digital Control and State Variable Methods', by M. Gopal, 4 <sup>th</sup> ed., McGraw Hill Education (2017) |

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| <br>सत्यं शिवं सुन्दरम्                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | The Maharaja Sayajirao University of Baroda<br>Faculty Technology and Engineering<br>Department of Electrical Engineering |                                                                                       | Academic Year            |               |          |            |      | 2021-22                                                                          |                                                                  |                                                                                                                |
| ME (E) (ACR): Regular Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                           |                                                                                       |                          |               |          |            |      |                                                                                  |                                                                  |                                                                                                                |
| Year                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | I                                                                                                                         | Core / <del>Elective</del> / Foundation<br>Embedded Applicationsin Industrial Control | Credits / Hours per week |               |          |            |      | L: 4 hrs/week<br>Pr. : 3hrs/week                                                 |                                                                  |                                                                                                                |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | II                                                                                                                        | Year of Introduction: 2021<br>Year of Syllabus Revision: NIL                          | Maximum Marks / Grade    |               |          |            |      | 100+50                                                                           |                                                                  |                                                                                                                |
| Mode of Transaction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                           | Lectures and Laboratory                                                               |                          |               |          |            |      |                                                                                  |                                                                  |                                                                                                                |
| Course Outcome (CO)<br>CO1: Design embedded system for industrial applications by interfacing different components of the system.<br>CO2: Develop embedded programs for low power microcontrollers for robotic applications.<br>CO3: Create ARM based basic and advanced programs for MEMs sensor-based applications.<br>CO4: Assess the different type of sensors, signal conditioning elements and Controller principles for real life applications.<br>CO5: Develop PLC Ladder diagram for various real-world problems/applications.<br>CO6: Explain the architecture and features of a digital signal processor for real-time implementations. |                                                                                                                           |                                                                                       |                          |               |          |            |      |                                                                                  |                                                                  |                                                                                                                |
| Unit No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Topic                                                                                                                     |                                                                                       | Contact Hours            | Weightage (%) | BT Level | CO         | PSO  | Element s of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD) | Releva nce to Local (L)/ Nationa l (N)/ Region al(R)/G lobal (G) | Relatio n to Gender (G), Environme nt and Sustainabil ity (ES), Human Values (HV)and Profession al Ethics (PE) |
| 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Introduction to embedded systems, Classification of architecture models, Networking in Embedded systems- (I2C, CANBUS,    |                                                                                       | 10                       | 16            | 5,6      | CO1<br>CO4 | PSO3 | SD                                                                               | G                                                                | PE                                                                                                             |



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|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|-----|-------------|--------------|----|---|----|
|   | MODBUS, USB), Serial and Parallel port interfaces, High-speed I/O interfacing, Transducers and their interfacing.                                                                                                                                                                                                                                                                                                                                                                                                   |    |    |     |             | PSO5         |    |   |    |
| 2 | Microcontrollers based Industrial Applications: Development of PID control Algorithm in Assy Lang. and controlling temperature through ON/OFF control or proportionate control. Interfacing of keyboard & 7-Segment Led Display & Lcd display, Industrial timer/counter, Power factor & Frequency measurement, Waveform generation using DAC, stepper motor controller. Interfacing of I2C Eeprom&Dac. Interfacing of Serial Printer using UART/RS232, HMI interfacing through RS485-Modbus communication protocol. | 16 | 35 | 6   | CO1<br>CO2  | PSO3<br>PSO5 | SD | G | PE |
| 3 | Controlling Principles and Methods, Design of analog/digital controllers, Discrete State Process Control, PLC Architecture and ladder logic programming, Industrial applications using PLC.                                                                                                                                                                                                                                                                                                                         | 10 | 20 | 5,6 | CO4,<br>CO5 | PSO3<br>PSO5 | SD | G | PE |
| 4 | C8051F340 microcontroller & Applications: Introduction to C8051F340 microcontroller, advance features e.g. ADC, USB, etc. Interfacing DC BLDC motor using PWM & interfacing IR sensors for Line follower robot. Open loop Speed control of DC motor.                                                                                                                                                                                                                                                                | 06 | 10 | 6   | CO1<br>CO2  | PSO3<br>PSO5 | SD | G | PE |
| 5 | DSP Overview: Architecture, Computing Unit IEEE floating point operation, multifunction computing, address generation, program sequencer, instruction cycle & operation, Interrupts, Timer, memory buses & interfacing, internal data transfer & context switching, hardware design, software preliminaries, syntax code notation, tools, Applications for servo control.                                                                                                                                           | 06 | 14 | 5   | CO6         | PSO3<br>PSO5 | SD | G | PE |
| 6 | Introduction to Cortex M7 microcontroller STM32F746: Enhanced Features, Block Diagram & Basic functions. Interfacing with MEM sensors, Accelerometer, Gyro.                                                                                                                                                                                                                                                                                                                                                         | 04 | 05 | 6   | CO3         | PSO3<br>PSO5 | SD | G | PE |

**Reference Books**

|    |                                                                         |
|----|-------------------------------------------------------------------------|
| 1. | Interfacing Sensors to the IBM PC – W. Tompkins, J.G. Webster (PH Intl) |
| 2. | Process Control Instrumentation Technology - Curtis D Johnson (4th Ed.) |
| 3. | D.V. Hall : Microprocessors And Interfacing, Programming and hardware.  |
| 4. | Datasheets for C8051F340 and Cortex-M7.                                 |
| 5. | Manuals for DSP Processor (C28X)                                        |

Laboratory : 6-10 Simulations/Experiments based on syllabus contents.

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|                                                                                                                                                                                                                                                                                                                                                                                                | <b>The Maharaja Sayajirao University of Baroda</b><br><b>Faculty Technology and Engineering</b><br><b>Department of Electrical Engineering</b> | <b>Academic Year</b>                                                                      |  |                                 |                      |                 | <b>2021-22</b>       |              |                                                                                        |                                                                      |                                                                                                                    |
| <b><u>ME (E) (ACR): Regular Programme</u></b>                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                |                                                                                           |  |                                 |                      |                 |                      |              |                                                                                        |                                                                      |                                                                                                                    |
| <b>Year</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>I</b>                                                                                                                                       | <b>Core / <del>Elective</del> / Foundation</b><br><b>Adaptive Filtering &amp; Control</b> |  | <b>Credits / Hours per week</b> |                      |                 | <b>L: 4 hrs/week</b> |              |                                                                                        |                                                                      |                                                                                                                    |
| <b>Semester</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>II</b>                                                                                                                                      | Year of Introduction: 2021<br>Year of Syllabus Revision: NIL                              |  | <b>Maximum Marks / Grade</b>    |                      |                 | <b>100</b>           |              |                                                                                        |                                                                      |                                                                                                                    |
| <b>Mode of Transaction</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                | Lectures                                                                                  |  |                                 |                      |                 |                      |              |                                                                                        |                                                                      |                                                                                                                    |
| <b>Course Outcome (CO)</b><br>CO1 : Illustrate various principles and fundamental concepts of System Identification<br>CO2: Analyze various statistical Optimization algorithms like LMS, LS, RLS etc. and use them for parameter estimation and prediction<br>CO3: Verify principles and fundamental concepts of Adaptive control<br>CO4: Apply Kalman filter theory for estimation and prediction and design adaptive control systems like and Model reference control system |                                                                                                                                                |                                                                                           |  |                                 |                      |                 |                      |              |                                                                                        |                                                                      |                                                                                                                    |
| <b>Unit No.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Topic</b>                                                                                                                                   |                                                                                           |  | <b>Contact Hours</b>            | <b>Weightage (%)</b> | <b>BT Level</b> | <b>CO</b>            | <b>PSO</b>   | <b>Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)</b> | <b>Relevance to Local (L)/ National (N)/ Regional (R)/Global (G)</b> | <b>Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)</b> |
| 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Mathematical Background for system identification - Probability, random variables, Stochastic process; Various types of                        |                                                                                           |  | 08                              | 17                   | 1,2,4           | CO2<br>CO1           | PSO2<br>PSO3 | SD                                                                                     | G                                                                    | PE                                                                                                                 |



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**ME ELECTRICAL (Automatic Control & Robotics)**

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|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|--------|------------|--------------------------------------|--|--|--|
|   | Deterministic and Stochastic models. State Space models, Parametric models, frequency domain models, polynomial models, Difference operator representations.                                                                                                                                                                                                       |    |    |        |            |                                      |  |  |  |
| 2 | Basics of linear filtering and adaptive filter theory, Wiener Filter as a linear estimator, Error performance surface; Estimation with bounded noise and constrained parameter estimation; Steepest Descent Algorithm, Stochastic gradient algorithm, convergence, LMS and its variants; On-line estimation schemes using Equation Error and Output Error methods. | 13 | 27 | 1,2,4  | CO2<br>CO1 | PSO2<br>PSO3                         |  |  |  |
| 3 | Linear Optimal Filtering and Prediction and state estimation; Prediction Error Filters, Algorithms based on pseudo-linear regressions, Convergence analysis of sequential algorithms.                                                                                                                                                                              | 05 | 06 | 2,4,3  | CO2<br>CO1 | PSO2<br>PSO3<br>PSO4                 |  |  |  |
| 4 | Windowing methods, Least Squares algorithm, Normal equations, Projection Operator, Orthogonalized Projection ; Computation of pseudo inverse, Matrix Inversion Lemma, Singular Value Decomposition; Recursive Least Squares algorithms and its variants; Estimation and prediction using Kalman Filter; Extended Kalman Filter                                     | 13 | 28 | 2,4,3  | CO3<br>CO4 | PSO1<br>PSO3<br>PSO4<br>PSO5<br>PSO6 |  |  |  |
| 5 | Direct and Indirect Control – One step ahead Adaptive control; Comparison between feedback control, robust control and adaptive control; System identification using persistence of excitation                                                                                                                                                                     | 07 | 12 | 2,4,3  | CO3<br>CO4 | PSO1<br>PSO3                         |  |  |  |
| 6 | Model Reference Adaptive Control; Adaptive algorithm for closed loop pole assignment; Adaptive controllers – Adaptive Minimum variance control, Stochastic MRAC. Applications of adaptive control                                                                                                                                                                  | 06 | 10 | 1,2, 4 | CO3<br>CO4 | PSO1<br>PSO3<br>PSO5                 |  |  |  |

**Reference Books**

|    |                                                                                                                    |
|----|--------------------------------------------------------------------------------------------------------------------|
| 1. | Simon Haykin, Adaptive Filter Theory, fourth edition, Prentice Hall, 2002                                          |
| 2. | G. C. Goodwin and K. S. Sin, Adaptive Filtering Prediction and Control. Englewood Cliffs, NJ: Prentice-Hall, 1984. |
| 3. | S. Sastry and M. Bodson, Adaptive Control: Stability, Convergence and Robustness. Prentice Hall, 1989.             |
| 4. | Ljung L. " System Identification : Theory for the user" Prentice Hall, NJ 1987                                     |
| 5. | Robust Adaptive Control – P A Ioannou& Jing Sun                                                                    |