AC- 29/06/2021

Item No.: 6.9

UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Mechatronics Engineering

Third Year with Effect from AY 2021-22

(REV- 2019 'C' Scheme) from Academic Year 2019 – 20

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019–2020)

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	**Third Year B.E. in Mechatronics Engineering**
2	Eligibility for Admission	**After Passing Second Year Engineering as per the Ordinance 0.6243**
3	Passing Marks	**40%**
4	Ordinances / Regulations (if any)	**Ordinance 0.6243**
5	No. of Years / Semesters	**8 semesters**
6	Level	~~P.G.~~ **/ U.G./** ~~Diploma / Certificate~~ (Strike out which is not applicable)
7	Pattern	~~Yearly~~ **/ Semester** (Strike out which is not applicable)
8	Status	~~New~~ **/ Revised** (Strike out which is not applicable)
9	To be implemented from Academic Year	**2021-2022**

Date

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering)of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. Choice based Credit and grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 12-13 weeks and remaining 2-3 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 171, wherein focus is not only on providing knowledge but also on building skills, attitude and self learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Second Year of Engineering from the academic year 2020-21. Subsequently this will be carried forward for Third Year and Final Year Engineering in the academic years 2021-22, 2022-23, respectively.

Dr. S. K. Ukarande
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Incorporation and implementation of Online Contents from NPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill based activities and project based activities. Self learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of ‘C ‘ scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme ‘A' and ‘B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self learning to learner. Learners are now getting sufficient time for self learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD’s/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Preface

Engineering education in India has to prepare budding minds for applying multidisciplinary knowledge for product and process innovation. Mechatronics is a new branch of engineering introduced in University of Mumbai from 2015, which synergistically applies the fundamentals of Mechanical, Electrical, Electronics and Information systems engineering to develop new products and processes. Thus Mechatronics focuses on development of products and processes that require combined application of multiple engineering domains.

Several changes in technological trends have happened since the introduction of last syllabus of Mechatronics in 2015. New avenues for synergistic application of fundamentals from multiple disciplines are opening up every day with technologies such as 3D Printing, Drones, IOT, Machine learning etc. are becoming popular. The curriculum is designed for preparing the students for a career in four major focus areas (a) Industrial Automation, (b) Embedded Systems (c) Digital Design and Manufacturing (d) Intelligent Control and Machine learning. There are upcoming career opportunities in all these domains. A conscious effort is made to include several technologies that are being promoted under the Industry 4.0 revolution.

The Updated Program Educational Objectives for this syllabus revision of the undergraduate program in Mechatronics Engineering are listed below;
1. To prepare the Learner in building technology systems through interdisciplinary approach.
2. To prepare the Learner to use modern tools embedding different disciplines of engineering in order to solve real life problems and prepare them for the fourth industrial revolution.
3. To prepare the Learner for career in Indian and Multinational Organisations and to excel in their Postgraduate studies; furthermore, to encourage and motivate the art of self-learning.
4. To inculcate a professional and ethical attitude, good leadership qualities in the Learner's thought process.

We trust this revised version of syllabus come up to the expectations of all stakeholders. We wish to place on record our sincere thanks and appreciations to the various contributors from the academia and industry for their most learned inputs in framing this syllabus.

Board of Studies in Mechanical Engineering

Dr. Vivek K. Sunnapwar : Chairman
Dr. S. M. Khot : Member
Dr. V. M. Phalle : Member
Dr. Siddappa Bhusnoor : Member
Dr. S.S. Pawar : Member
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Program Structure for Third Year Engineering
Semester V & VI
UNIVERSITY OF MUMBAI
(With Effect from 2021-2022)

Semester V

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
MTC501	CAD and CAE	3	--	--	3	--	--	3
MTC502	Sensors and Actuators	3	--	--	3	--	--	3
MTC503	Mechatronic Systems Modelling and Control	3	--	--	3	--	--	3
MTC504	Embedded Systems	3	--	--	3	--	--	3
MTDO501	Department Optional Course – 1	3	--	--	3	--	--	3
MTL501	Sensors and Actuators Laboratory	--	2	--	--	1	--	1
MTL502	Mechatronic Systems Modelling and Control Laboratory	--	2	--	--	1	--	1
MTL503	Embedded Systems Laboratory	--	2	--	--	1	--	1
MTL504	Professional Communication and Ethics-II	--	2*+2	--	--	2	--	2
MTPBL501	Mini Project – 2 A	--	4$	--	--	2	--	2
Total					**15**	**07**		**22**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract /Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test1	Test2	Avg.					
MTC501	CAD and CAE	20	20	20	80	3	--	--	100
MTC502	Sensors and Actuators	20	20	20	80	3	--	--	100
MTC503	Mechatronic Systems Modelling and Control	20	20	20	80	3	--	--	100
MTC504	Embedded Systems	20	20	20	80	3	--	--	100
MTDO501	Department Optional Course – 1	20	20	20	80	3	--	--	100
MTL501	Sensors and Actuators Laboratory	--	--	--	--	--	25	25	50
MTL502	Mechatronic Systems Modelling and Control Laboratory	--	--	--	--	--	25	25	50

MTL503	Embedded Systems Laboratory	--	--	--	--	--	25	25	50
MTL504	Professional communication and ethics –II	--	--	--	--	--	50	--	50
MTPBL501	Mini Project – 2 A	--	--	--	--	--	25	--	25
Total		**--**	**--**	**100**	**400**	--	**150**	**75**	**725**

* Theory class to be conducted for full class

$ indicates work load of Learner (Not Faculty), for Mini Project

Department Optional Course - 1

1) Signals and Systems
2) Production Processes
3) Operating Systems

Course Code	Course Name	Credits
MTC501	**CAD and CAE**	**03**

Prerequisite: FEL203 Engineering Graphics , MTL304 CAD Modelling Laboratory ,MTC404 Strength of Materials

Objectives:

1. To introduce new and exciting field of Intelligent CAD and CAE with particular focus on engineering product design.
2. To develop a holistic view of initial competency in engineering design by modern computational methods.
3. To introduce Biomedical Modelling
4. To introduce techniques of analysis and optimization of engineering components.

Outcomes: Learner will be able to...

1. Identify proper computer graphics techniques for geometric modelling.
2. Transform, manipulate objects and store and manage data.
3. Create and manipulate 3D Models based on Medical imaging data.
4. Perform design analysis.
5. Identify the tools for Analysis of a complex engineering component.
6. Demonstrate understanding of design optimization.

Module	Details	Hrs.
1.	**Computer Graphics** 1.1 Introduction: Scope of CAD in product life cycle, CAD hardware and software, 2D and 3D computer graphics representation. 1.2 Parametric representation of curves and surfaces: Synthetic Curves - Bezier curves, Hermite Curves, B-spline curves. 1.3 Solid Modeling: Constructive solid geometry (CSG), Boundary Representation (B-Rep), Wire Frame Modeling, Solid Modeling, Surface Modeling, Parametric Modeling, Feature based modeling, Constraint Based Modeling.	07
2.	**Geometric Transformation** 2.1 Homogeneous Coordinate system, Matrix representation, Concatenations, 2D and 3D geometric transformation (Translation, Reflection, Scaling, Rotation)	06
3.	**BioMedical Modeling** 3.1 Introduction to medical imaging: Computed tomography (CT), Cone beam CT (CBCT), Magnetic resonance (MR), Noncontact surface scanning, Medical scan data , Point cloud data 3.2 Working with medical scan data: Pixel data operations, Using CT data: a worked example, Point cloud data operations, Two-dimensional formats, Pseudo 3D formats, True 3D formats, File management and exchange	06
04	**Design Analysis** 4.1. Basic principles of Machine Design. Theories of failures, Factor of safety. Variable Stresses, Fatigue Cycle and Failures, Endurance Limit, Soderberg and Goodma Design Criteria. 4.2. **Introduction to CAE** Fundamentals of computer aided engineering, CAE includes mass property calculations, kinematic analysis and animation (movement, visualization, simulation and FEA.)	06

05	**Finite Element Analysis:** 5.1 Introductory Concepts: Introduction to FEM, Historical Background, General FEM procedure, Applications of FEM in various fields Advantages and disadvantages of FEM Definitions of various terms used in FEM like element, order of the element, internal and external node/s, degree of freedom, primary and secondary variables, boundary conditions. 5.2 One dimensional second order equations - discretization-element types - linear and higher order elements -derivation of shape functions and stiffness matrices and force vectors. 5.3 Assembly of Matrices- solution of problems in one dimensional structural analysis, heat transfer (stepped and taper bars, spring-Cart Systems). Case study using FEA Software.	08
06	**Optimization Techniques** 6.1. **Design Optimization** Design Optimization process flowchart, Problem formulation: Design Variables, Constraints , Objective function, Variable bounds. Single and multivariable problem formulation examples. Optimization methods and their classification. Iterative optimization procedure, Local and global minimum, Convergence criteria. Golden Section search algorithm and its implementation. 6.2. **Structural Optimization**: Mathematical formulation, Structural optimization types : Sizing, Shape and Topology. Weight minimization of 2 bar truss subject to stress and Displacement constraints. Case study on Topology optimization.	06

<u>Assessment</u>:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 35% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein sub-questions of 2 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.(e.g. Suppose Q.2 has part (a) from module3 then part (b) will be from any module other than module 3)
5. In question paper weightage of each module will be proportional to number of respective lecture hrs as mentioned in the syllabus.

Text/Reference Books:

1. CAD/ CAM, Theory & Practice, Ibrahim Zeid, R. Sivasubramanian, Tata McGraw Hill Publications
2. CAD/CAM Principles and Applications, P. N. Rao, Tata McGraw Hill Publications
3. CAD/CAM Computer Aided and Manufacturing, Mikell P. Groover and Emory W. Zimmers, Jr., Eastern Economy Edition
4. Medical Modelling: The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
5. Design of machine elements -- V. B. Bhandari. Tara Mc-Graw Hill Pub.
6. Design of machine elements -- Sharma,Purohil. Prentice Hall India Pub.
7. MACHINE DESIGN An Integrated Approach *Robert L. Norton* Prentice Hall
8. "Text book of Finite Element Analysis" by Seshu P, Prentice Hall of India
9. Finite Element Method by JNReddy, TMH

10. 'Introduction to Finite Elements in Engineering, Chandrupatla and Belegundu,Pearson Education
11. “Introduction To Optimum Design” Jasbir S. Arora 2012 Elsevier Inc.
12. “Multidiscipline Design Optimization” Garret N. Vanderplaats
13. “Optimization Methods for Engineering Design Applications and Theory” Alan R. Parkinson Richard J. Balling John D. Hedengren
14. “Topology Optimization Theory, Methods, and Applications” M.P. Bendse . o. Sigmund Springer-Verlag Berlin Heidelberg GmbH

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/102/112102101/
https://nptel.ac.in/courses/112/104/112104031/
https://nptel.ac.in/courses/112/104/112104193/
https://nptel.ac.in/courses/112/104/112104116/
https://nptel.ac.in/courses/112/105/112105235/

Course Code	Course Name	Credits
MTC502	**Sensors and Actuators**	**03**

Prerequisite: MTC304 Basic Electronics and Digital Circuit Design ,MTC305 Electrical Circuits and Machines , MTC403 Thermal and Fluid Engineering

Objectives:

1. Study of means of measuring various physical variables.
2. Study of different types of actuators.

Outcomes: Learner will be able to...

1. Identify sensor characteristics including calibration and error analysis
2. Implement common techniques of signal conditioning
3. Understand how different physical variables are measured and illustrate their working principles
4. Identify different types of actuators and their implementation
5. Understand new technologies of actuation
6. Identify and select sensors and actuators for industrial applications

Module	Details	Hrs.
01	Significance of Sensor Measurements, Classification of sensors based on domain, technology and operation. **Static characteristics:** Static calibration, Linearity, Static Sensitivity, Accuracy, Static error, Precision, Reproducibility, Threshold, Resolution, Hysteresis, Drift, Span & Range etc. **Dynamic Characteristics:** Sensor bandwidth and frequency response **Signal conditioning:** Amplifier, Conversion, Filtering, Impedance Buffering Types of errors, Effect of component errors, Probable errors.	06
02	**Proximity and Distance Measurement**: Limit Switch, Reed switch, Inductive, Capacitive, Hall Effect Sensors, Optical and Ultrasonic distance measurement. **Displacement Measurement:** Transducers for displacement, potentiometer, LVDT, Capacitance Types, Digital Transducers (optical encoder), **Measurement of Angular Velocity**: Tachometers, Digital tachometers and Stroboscopic Methods. MEMS 3 axis Gyroscope. **Acceleration Measurement**, theory of accelerometer and vibrometers, practical accelerometers, strain gauge based and piezoelectric accelerometers. MEMS 3 Axis Accelerometer.	08
03	**Strain Measurement:** Theory of Strain Gauges, gauge factor, temperature Compensation, orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors **Pressure Measurement:** Microphones, Elastic pressure transducers, bellows and piezoelectric pressure sensors, High Pressure Measurements, Bridge man gauge. Vacuum measurement, **Flow Measurement:** Bernoullis flowmeters, Ultrasonic Flowmeter, Magnetic flow meter, rotameter. **Temperature Measurement:** Electrical methods of temperature measurement, Resistance thermometers, Thermistors and thermocouples, Pyrometers, thermal cameras. Special Sensors: Chemical Sensors: (Zirconium oxide ceramic type Oxygen sensors, Quartz Crystal Microbalance sensor). Optical Light sensors, Tactile/Touch sensors, Cameras and image analysis.	08
04	**Electrical Actuating systems** **DC motors:** Review of DC motor, Modeling of DC motor behaviour, Servo Amplifier, DC motor drive. DC Servo Motors **Stepper Motors:** Characteristics of a Stepper motor, Classification of a Stepper motor, Principle of Operation, Step Angle, Electrical model of energized coil, Drive method,	06

	Stepper motor performance. **Induction motors:** Three phase motor, induction motor characteristics **Linear Actuators:** Voice Coil Actuators, solenoids	
05	**Pneumatic and Hydraulic actuating systems** Components of pneumatic and hydraulic systems, pumps, compressor, filter, control valves, pressure regulation, relief valves, accumulator. Single Acting and Double acting cylinders, Hydraulic motors. Simple single actuator circuits. **Harmonic drive, Comb drive.** **Smart Material Actuators:** Piezoelectric transducers, Electro active polymers, Shape Memory alloys, Artificial Muscle materials	05
06	**Selection criteria of sensors for mechatronic systems**: Application requirement, Instrument ratings, Geometric limitations, Environmental conditions, Power requirements, Cost-related economic aspects **Consideration during with actuator selection:** Actuator bandwidth and frequency response, actuator range, power and energy considerations, trade-offs between force/displacement or torque/speed, control systems and electronics, industrial considerations. DC Motor Selection Heat dissipation in DC motor, Velocity Profile Optimization, Inertia matching. Stepper Motor selection considerations. Actuator sizing for industrial application.	06
Self-study Topic	Wheatstone Bridge circuit,	**--**

Assessment:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 35% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein sub- questions of 2 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.(e.g. Suppose Q.2 has part (a) from module3 then part (b) will be from any module other than module 3)
5. In question paper weightage of each module will be proportional to number of respective lecture hrs as mentioned in the syllabus.

Text/Reference Books:

1. Sensors and Actuators: Control System Instrumentation -Clarence W Silva, CRC Press USA
2. Sensors and Actuators in Mechatronics: Design and Applications: Andrzej M Pawlak, CRC Press USA
3. Measurement Systems (Applications and Design) 5th ed.- E.O. Doebelin - *McGraw Hill.*
4. Mechatronics Integrated technologies for intelligent machines. A. Smaili F. Mrad Oxford university press
5. Mechanical Engineering Measurement - Thomas Beckwith, N.Lewis Buck, Roy Marangoni - Narosa Publishing House, Bombay.
6. Mechanical Engineering Measurements - A. K. Sawhney – DhanpatRai & Sons, New Delhi.
7. Instrumentation Devices & Systems - C.S. Rangan & G.R.Sarrna - Tata McGraw Hill.
8. Instrumentation & Mechanical Measurements - A.K. Thayal.
9. Optomechatronics: Fusion of Optical and Mechatronics Engineering By Hyungsuck Cho

10. Smart Structures: Analysis and Design, AV Shrinivasan and D Micheal Macfarland. Cambridge University Press
11. Smart Materials and Structures: MV Gandhi and BS Thomson. Chapman and Hall
12. Applied Mechatronics- A. Smaili and F. Mrad, OXFORD university press.

Links for online NPTEL/SWAYAM courses:
https://nptel.ac.in/courses/112/107/112107242/
https://nptel.ac.in/courses/108/105/108105064/

Course Code	Course Name	Credits
MTC503	**Mechatronic Systems Modelling and Control**	**03**

Prerequisite: MTC402 Kinematics of Machinery, MTC403 Thermal and Fluid Engineering, MTC305 Applied Electrical and Electronics Engineering

Objectives:

1. To study first principle modelling of Mechatronic systems
2. To study open loop and closed loop system
3. To study the time response of first and second order system
4. To study the concept of stability and criteria for stability and solve the problem based on it
5. To study the frequency response through polar plot.
6. To study the compensation technique used to stabilize the system

Outcomes: Learner will be able to...

1. Define a first principle model of a Mechatronic system
2. Define the open loop and closed loop system
3. Design time response of first and second order system and basic state variable analysis
4. Sketch the frequency response of second order systems using polar plot and bode plots.
5. Design a compensator to stabilize the unstable system.

Module	Detailed Contents	Hrs.
01	**6.1 Physical system modeling** Bond Graph Modelling : Theory , Concepts and Definitions, Power Variables, Energy Variables, Analogy of Energy Variables, Bond Graph Elements : Sources, One port Passive (Resistive, Storage, Inertia) Active, Junctions , Two Port Elements, Sensors, Information Bonds, Causality, Sequential Causality Assignment Procedure, Paths, Types, Derivative Causality, Closed Causal Paths , Bond Graphs for Electrical Systems, Bond Graphs for Mechanical Systems, Bond graphs for Multi Domain Systems. Deriving Block Diagram Model from Bond Graph Model. **Modeling in Frequency Domain** Transfer function representation of physical systems. Block diagrams & Signal flow graphs, Reduction of Block diagrams, Masons Rule. **State Space Representation** State Space Representation of systems. Converting transfer function to state space. Converting from State Space to a Transfer Function. Introduction to automatic control and its applications, Nomenclature in Automatic Control, Open and Closed loop configurations.	10
02	**Time Domain Response:** Introduction, Poles, Zeros, and System Response, Time domain performance specification First-Order Systems, Second-Order Systems: General Second-Order System, Underdamped Second-Order Systems, System Response- with additional Poles, with Zeros; Steady state errors and static error constants in unity feedback control systems, Static Error Constants and System Types; Steady-State Error for Non-unity Feedback Systems; Limitations of time domain analysis. Laplace Transform Solution of State Equations.	08
03	**Root Locus Method** Introduction, Defining the Root Locus, Properties of the Root Locus, Sketching the Root Locus, Transient Response Design via Gain Adjustment, Generalized Root Locus, Root Locus for Positive-Feedback Systems, Pole Sensitivity, Design with Root Locus, Improving Steady-State Error and transient response via Cascade Compensation. Example of DC Motor as a plant.	05
04	**Frequency Response Analysis** Asymptotic Approximations: Bode Plots, Polar Plots; Stability Analysis-Gain Margin and Phase Margin with Bode Plots, Closed-Loop Transient and Open- Loop Frequency Responses, Relation Between- Closed-Loop Transient and Closed-Loop Frequency Responses, Steady-State Error Characteristics from Frequency Response.	05

05	**Stability & Compensation Techniques** **Stability:** Concepts, absolute, asymptotic, conditional and marginal stability, Routh-Hurwitz Criterion, Special Cases, of Routh-Hurwitz Criterion: Stability in State Space, Stability analysis with Root locus technique. **Compensation**-Physical Realization of compensation. Concepts, series/parallel/ series-parallel/feedback compensation, Lag/Lead/Lag-Lead networks for compensation **Case Study** Case study of analog control system design with practical approach- PI Velocity Control of a DC Motor.	06
06	**Digital Control:** Introduction to Digital control systems, comparison with analog control systems, Implementation of Digital controller in Temperature Control System and Digital Power Supply, Digital Signal controller based Implementation technique.	05
Self-study Topic	Laplace Transform Review, Signal flow graphs of state equations.	**--**

Assessment:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 35% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein sub- questions of 2 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.(e.g. Suppose Q.2 has part (a) from module3 then part (b) will be from any module other than module 3)
5. In question paper weightage of each module will be proportional to number of respective lecture hrs as mentioned in the syllabus.

Text/Reference Books:

1. Norman S. Nise, "*Control System Engineering*", John Wiley & Sons, Inc, Sixth Edition
2. Rochdi Merzouki , Arun Kumar Samantaray, Pushparaj Mani Pathak , Belkacem Ould Bouamama "Intelligent Mechatronic Systems Modeling, Control and Diagnosis"
3. Victor M. Hernández-Guzmán R. Silva-Ortigoza "Automatic Control with Experiments" Springer
4. B. C. Kuo, "Automatic Control System", Prentice Hall of India, Seventh edition, 2001.
5. Nagraath Gopal "Control Systems Engineering -Principles and Design" New Age Publishers
6. M. Gopal, "Modern Control System Theory", Wiley Eastern Ltd., New Delhi.
7. K. Ogata, "Modern Control Engineering", 3 ed. Prentice Hall of India (P) Ltd., New Delhi.
8. Dr. K.P. Mohandas, "Modern Control Engineering", revised edition, Sanguine Publishers, Bangalore, 2006.

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/107/112107214/
https://nptel.ac.in/courses/108/106/108106098/
https://nptel.ac.in/courses/107/106/107106081/

Course Code	Course Name	Credits
MTC504	**Embedded Systems**	**03**

Prerequisite: MTC 304 : Basic Electronics & Digital Circuit Design, MTC 305 : Electrical Circuits & Machines, MTC 405 : Application of Integrated Circuits

Objectives:

1. To develop background knowledge and core expertise in area of embedded systems.
2. To teach applications of microcontrollers in embedded systems

Outcomes: Learner will be able to...

1. Describe the Components, importance and applications of embedded system
2. Describe architecture, interface peripherals and program 8051 microcontrollers
3. Describe architecture, interface peripherals and program ARM7 microcontrollers
4. Illustrate basic terminologies of software development and real time operating system
5. Design microcontroller based embedded systems for various applications

Module	Details	Hrs.
01	**General Concepts** **Basic Concepts**: Microprocessor and Microcontroller, Von Neumman and Harward, Intel 8085 microprocessor architecture (only) **Introduction to Embedded systems**: Design Metrics, Examples of embedded systems, hardware/software co-design, Embedded micro controller cores (ARM, RISC, CISC, and SOC), Embedded memories, Architecture of Embedded Systems Introduction to IOT	5
02	**8051 Microcontroller** **Architecture**: Features, architecture and pin configurations, CPU timing and machine cycle, Input / Output ports, Memory organization, Counters and timers, Interrupts, Serial data input and output **8051 Assembly Language Programming**: Instruction set, Addressing mode, Assembler directives and programs **8051 Interfacing**: LED, LCD, Seven Segment Display, keyboard, ADC, Stepper Motor, Relay and Serial Communication	12
03	**Advanced Microcontrollers** **Architecture**: Features of ARM Microcontroller, Operating modes, Architecture, Registers, CPSR, Pipeline, Exceptions, interrupt vector table, memory management, ARM7 processor families **ARM7 Programming**: Instruction set, Addressing mode and programs **MSP 430**: Features, architecture and programming	8
04	**Embedded Software Development** Assemblers, linkers and loaders. Binary file formats for processor executable files. Typical structure of timer-interrupt driven programs. GNU-GCC compiler introduction **Embedded C-programming concepts**: Optimizing for Speed/Memory needs, Interrupt service routines, macros, functions, modifiers, data types, device drivers	5
05	**Real Time Operating System** Real Time Operating System Concepts, Kernel Structure, Critical Sections, Multitasking, Task Management, Time Management, Schedulers, Event Control Blocks, Priorities, Deadlocks, Synchronization, Semaphore Management, Mutual Exclusion, RTOS implementation	5
06	**Applications Case Studies** - Consumer and Home**:** An IoT based home automation using android application - Medical**:** Health Monitoring using Embedded System - Robotics: Pick and place Robot / Autonomous robot for surveillance	4

Self-study Topic	1) TinkerCAD web platform for Arduino based embedded system 2) Raspberry pi microcontroller	

Internal Assessment:

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

Text/Reference Books:

1. Microprocessor architecture and applications with 8085: By Ramesh Gaonkar (Penram International Publication).
2. M. A. Mazidi, J. G. Mazidi and R. D. Mckinlay, "The 8051 Microcontroller & Embedded systems", Pearson Publications, Second Edition 2006.
3. C. Kenneth J. Ayala and D. V. Gadre, "The 8051 Microcontroller & Embedded system using assembly & 'C' ", Cengage Learning, Edition 2010.
4. Andrew Sloss, Dominic Symes, and Chris Wright, "ARM System Developer's Guide" Morgan Kaufmann Publishers, First Edition 2004.
5. James A. Langbridge, "Professional Embedded Arm Development", Wrox, John Wiley Brand& Sons Inc., Edition 2014
6. Frank Vahid and tony Gavages "Embedded system design – A unified hardware / software introduction", Wiley publication, Third edition 2002.
7. Embedded/Real-Time Systems: Concepts, Design & Programming – Dr. K. V. K. K. Prasad, Dreamtech Press, India.
8. Rajkamal, Embedded Systems - Architecture, Programming and Design, Tata McGraw Hill, Second edition, 2009

Links for online NPTEL/SWAYAM courses:

1) Introduction to Embedded system design : https://nptel.ac.in/courses/108/102/108102169/
2) Embedded Systems: https://nptel.ac.in/courses/108/102/108102045/
3) Microprocessors & Microcontrollers: https://nptel.ac.in/courses/108/105/108105102/
4) Microcontrollers & Applications : https://nptel.ac.in/courses/117/104/117104072/

Course Code	Course Name	Credits
MTL501	**Sensors and Actuators Laboratory**	**01**

Prerequisite: MTL303 Electrical and Electronics Workshop, MTL404 Technical Computing Laboratory, MTL403 Thermal and Fluid Engineering Lab,

Objectives:

1. Study of means of measuring various physical variables.
2. Introduce virtual instrumentation
3. Study of different types of sensors and actuators.
4. Selection and design of

Outcomes: Students will be able to…

1. Measure different physical variables for Mechatronic applications.
2. Design virtual instruments
3. Identify and select proper sensors for specific applications
4. Interfacing different types sensors and actuators
5. Design and implement systems using sensors and actuators

Suggested List of laboratory experiments (Minimum Eight):

Sr. No.	Experiment List
01	Design of virtual instrumentation set up for measurement of any mechanical characteristics using any software platform
02	Design of virtual instrumentation set up for actuating mechanical system using any software platform
03	Experimental characterization of DC motor
04	Experimental characterization of any one of the sensor.
05	Study of smart material actuators
06	Dynamic characterization and error analysis of any one of the measurement system
07	Characterization of any Displacement Sensor (e.g. LVDT)
08	Design based exercise for development of hydraulic/pneumatic circuit for an industrial application
09	Design based experiment aiming selection of actuator for industrial application.
10	Interfacing and programmed control of Servo motors
11	Velocity profile based control of DC Motor
12	Stepper motor based linear motion mechanism actuation.

Term Work:

Term work consists of performing minimum 10 practical mentioned as above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work.

The distribution of marks for term work shall be as follows:

- Laboratory work (Experiment/journal) : 20 marks.
- Attendance (Theory and Practical) : 05Marks

End Semester Examination:

Pair of Internal and External Examiner should conduct Practical and Oral. Practical exam (15 marks) will be on any one of the experiments from the list and oral exam (10 marks) will be based on the entire syllabus of the laboratory.

Course Code	Course Name	Credits
MTL502	**Mechatronic Systems Modelling and Control Laboratory**	**01**

Prerequisite: MTL302 Applied Electronics Laboratory-I, MTL401Applied Electronics Laboratory-II , MTL404 Technical Computing Laboratory

Objectives:

1. Transfer Function and State Space Modelling and simulation of Physical systems
2. To study the time response of first and second order system
3. To study the error analysis of different control system
4. To study the compensation technique used to stabilize the system

Outcomes: Students will be able to…

1. Model and simulate physical systems using software tools
2. Perform Parameter Identification
3. Define the open loop and closed loop system
4. Simulate time and frequency response of first and second order systems.
5. Simulate the control system for getting different response.
6. Design of controller for position/velocity control of DC Motor

Suggested List of laboratory experiments (Minimum Eight):

Sr. No.	Experiment List
01	Mathematical (Transfer Function) modelling and simulation of any Mechanical System and any Electrical System using Matlab® (Simulink) / Scilab (xcos) or similar software
02	Mathematical (State Space) modelling and simulation of any Mechanical System and any Electrical System using Matlab® / Scilab or similar software
03	Mathematical (Transfer Function) modelling of DC Motor using Matlab® (Simulink) / Scilab (xcos) or similar software
04	D.C. Motor Parameter Identification
05	Experiment on components of control system
06	Transient response of 1st order & 2nd order system
07	Frequency response of 1st order & 2nd order system
08	Time and Frequency Response simulation in Matlab®/Scilab
09	Steady state error analysis of different types of systems
10	Simulation for Stability analysis
11	Design of Proportional Controller of Velocity for a DC Motor in Matlab®/Scilab
12	Frequency Response based Design of PD Position Control of a DC Motor in Matlab®/Scilab

Term Work:

Term work consists of performing minimum 10 practical mentioned as above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work.
The distribution of marks for term work shall be as follows:

- Laboratory work (Experiment/journal) : 20 marks.
- Attendance (Theory and Practical) : 05Marks

End Semester Examination:

Pair of Internal and External Examiner should conduct Practical and Oral. Practical exam (15 marks) will be on any one of the experiments from the list and oral exam (10 marks) will be based on the entire syllabus of the laboratory.

Course Code	Course Name	Credits
MTL503	**Embedded Systems Laboratory**	**01**

Pre-requisite: MTL302 Applied Electronics Laboratory-I, MTL303 Electrical and Electronics Workshop

Objectives:

1. To develop background knowledge and core expertise in area of embedded systems.
2. To teach applications of microcontrollers in embedded systems

Outcomes: Learner will be able to...

1. Describe architecture, interface peripherals and program 8051 microcontrollers.
2. Describe architecture, interface peripherals and program ARM7 microcontrollers
3. Explain the basic terminologies of software development and real time operating system.
4. Design microcontroller based embedded systems for various applications

List for Practical:

1. Experiment on programming of 8051
2. Two Experiments on interfacing of 8051
3. Experiment on programming of ARM
4. Two Experiments on interfacing of ARM
5. Experiment on MSP430
6. Experiment on interfacing of MSP430
7. Experiment on RTOS. Converting Exsiting Windows and LINUX as RTOS by configuring QNX Neutrino (using Virtual Machine)
8. Mini project

Term Work:

Term work shall consist of 8 experiments mentioned above and should be set to have well predefined inference and conclusion. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
Distribution of marks for Term work shall be as follows:

Laboratory work (experiments/assignments): 15 marks

Mini Project : 05 marks

Attendance (Theory and practical's): 05 marks

Oral Examination:

Pair of Internal and External Examiner should conduct Practical and Oral. Practical exam (15 marks) will be on any one of the experiments from the list and oral exam (10 marks) will be based on the entire syllabus of the laboratory.

Course Code	Course Name	Credits
MTL504	**Professional Communication and Ethics-II**	**02**

Objectives:

Learners should be able to:

1. Discern and develop an effective style of writing important technical/business documents.
2. Investigate possible resources and plan a successful job campaign.
3. Understand the dynamics of professional communication in the form of group discussions, meetings, etc. required for career enhancement.
4. Develop creative and impactful presentation skills.
5. Analyse personal traits, interests, values, aptitudes and skills.
6. Understand the importance of integrity and develop a personal code of ethics.

Outcomes: Learners will be able to…

1. Plan and prepare effective business/ technical documents which will in turn provide solid foundation for their future managerial roles.
2. Strategize their personal and professional skills to build a professional image and meet the demands of the industry.
3. Emerge successful in group discussions, meetings and result-oriented agreeable solutions in group communication situations.
4. Deliver persuasive and professional presentations.
5. Develop creative thinking and interpersonal skills required for effective professional communication.
6. Apply codes of ethical conduct, personal integrity and norms of organizationalbehaviour.

MODULE	DETAILS	HRS
MODULE 1 - ADVANCED TECHNICAL WRITING :PROJECT/PROBLEM BASED LEARNING (PBL)		
1.1. Purpose and Classification of Reports	**Classification on the basis of:** ● Subject Matter (Technology, Accounting, Finance, Marketing, etc.) ● Time Interval (Periodic, One-time, Special) ● Function (Informational, Analytical, etc.) ● Physical Factors (Memorandum, Letter, Short & Long)	**06**
1.2. Parts of a Long Formal Report	● Prefatory Parts (Front Matter) ● Report Proper (Main Body) ● Appended Parts (Back Matter)	
1.3. Language and Style of Reports	● Tense, Person & Voice of Reports ● Numbering Style of Chapters, Sections, Figures, Tables and Equations ● Referencing Styles in APA & MLA Format ● Proofreading through Plagiarism Checkers	

1.4. Definition, Purpose & Types of Proposals	• Solicited (in conformance with RFP) & Unsolicited Proposals • Types (Short and Long proposals)	
1.5. Parts of a Proposal	• Elements • Scope and Limitations • Conclusion	
1.6. Technical Paper Writing	• Parts of a Technical Paper (Abstract, Introduction, Research Methods, Findings and Analysis, Discussion, Limitations, Future Scope and References) • Language and Formatting • Referencing in IEEE Format	
MODULE 2 - EMPLOYMENT SKILLS		
2.1. Cover Letter & Resume	• Parts and Content of a Cover Letter • Difference between Bio-data, Resume & CV • Essential Parts of a Resume • Types of Resume (Chronological, Functional & Combination)	**06**
2.2 Statement of Purpose	• Importance of SOP • Tips for Writing an Effective SOP	
2.3 Verbal Aptitude Test	• Modelled on CAT, GRE, GMAT exams	
2.4. Group Discussions	• Purpose of a GD • Parameters of Evaluating a GD • Types of GDs (Normal, Case-based & Role Plays) • GD Etiquettes	
2.5. Personal Interviews	• Planning and Preparation • Types of Questions • Types of Interviews (Structured, Stress, Behavioural, Problem Solving & Case-based) • Modes of Interviews: Face-to-face (One-to one and Panel) Telephonic, Virtual	
MODULE 3 - BUSINESS MEETINGS		
3.1. Conducting Business Meetings	• Types of Meetings • Roles and Responsibilities of Chairperson, Secretary and Members • Meeting Etiquette	**02**
3.2. Documentation	• Notice • Agenda • Minutes	

MODULE 4 -TECHNICAL/ BUSINESS PRESENTATIONS		
4.1. Effective Presentation Strategies	• Defining Purpose • Analysing Audience, Location and Event • Gathering, Selecting &Arranging Material • Structuring a Presentation • Making Effective Slides • Types of Presentations Aids • Closing a Presentation • Platform Skills	**02**
4.2 Group Presentations	• Sharing Responsibility in a Team • Building the contents and visuals together • Transition Phases	
MODULE 5 - INTERPERSONAL SKILLS		
5.1. Interpersonal Skills	• Emotional Intelligence • Leadership & Motivation • Conflict Management & Negotiation • Time Management • Assertiveness • Decision Making	**08**
5.2 Start-up Skills	• Financial Literacy • Risk Assessment • Data Analysis (e.g. Consumer Behaviour, Market Trends, etc.)	
MODULE 6 - CORPORATE ETHICS		
6.1. Intellectual Property Rights	• Copyrights • Trademarks • Patents • Industrial Designs • Geographical Indications • Integrated Circuits • Trade Secrets (Undisclosed Information)	**02**
6.2. Case Studies	• Cases related to Business/ Corporate Ethics	

List of Assignments For Termwork

(In the form of Short Notes, Questionnaire/ MCQ Test, Role Play, Case Study, Quiz, etc.)

1. Cover Letter and Resume
2. Short Proposal
3. Meeting Documentation
4. Writing a Technical Paper/ Analysing a Published Technical Paper
5. Writing a SOP
7. IPR
8. Interpersonal Skills
9. Aptitude test (Verbal Ability)

Note:

1. The Main Body of the project/book report should contain minimum 25 pages (excluding Front and Back matter).
2. The group size for the final report presentation should not be less than 5 students or exceed 7 students.
3. There will be an end–semester presentation based on the book report.

Guidelines for Internal Assessment

Term Work	25 Marks
Assignments	10 Marks
Attendance	05 Marks
Presentation slides	05 Marks
Book Report (hard copy)	05 Marks
Internal Oral -	25 Marks

Oral Examination will be based on a GD & the Project/Book Report presentation.

Group Discussion	10 Marks
Project presentation (Individual Presentation)	10 Marks
Group Dynamics	05 Marks

Text/Reference Books:

1. Arms, V. M. (2005). Humanities for the engineering curriculum: With selected chapters from Olsen/Huckin: Technical writing and professional communication, second edition. Boston, MA: McGraw-Hill.
2. Bovée, C. L., &Thill, J. V. (2021). Business communication today. Upper Saddle River, NJ: Pearson.
3. Butterfield, J. (2017). Verbal communication: Soft skills for a digital workplace. Boston, MA: Cengage Learning.
4. Masters, L. A., Wallace, H. R., & Harwood, L. (2011).Personal development for life and work. Mason: South-Western Cengage Learning.
5. Robbins, S. P., Judge, T. A., & Campbell, T. T. (2017). Organizational Behaviour. Harlow, England: Pearson.
6. Meenakshi Raman, Sangeeta Sharma (2004) Technical Communication, Principles and Practice. Oxford University Press
7. Archana Ram (2018) Place Mentor, Tests of Aptitude For Placement Readiness. Oxford University Press
8. Sanjay Kumar &PushpLata (2018). Communication Skills a workbook, New Delhi: Oxford University Press.

Virtual Labs

https://ve-iitg.vlabs.ac.in/- Virtual English and Communication Virtual Lab, IIT Guwahati

http://vlabs.iitb.ac.in/vlabs-dev/labs/communication/- Professional Communication Virtual Lab, IIT Bombay

Course Code	Course Name	Credits
MTDO501	**Signals and Systems**	**03**

Prerequisite: MTC301 Engineering Mathematics-III

Objectives

1. To introduce students to the idea of signal and system analysis and characterization in time and frequency domain.
2. To provide foundation of signal and system concepts to areas like mechatronics, communication, control and comprehend applications of signal processing in communication systems

Outcomes: Learner will be able to...

1. Classify and Analyze different types of signals and systems
2. Analyze CT - LTI signals and systems in transform domain using Laplace Transform
3. Analyze and realize DT - LTI signals and systems in transform domain using Z Transform
4. Represent signals using Fourier Series and Analyze the systems using the Fourier Transform.
5. Demonstrate the concepts learnt in Signals and systems Course using the Modern Engineering Tools.

Module	Unit No.	Details	Hrs.
01	**1.1**	**Introduction to Signals and Systems:** Signal Definition, Representation of Signal, Operations performed on Dependent Variable, Operations Performed on Independent Variables, Fundamental Signals - Unit Step, Unit Impulse, Unit Ramp, Sinusoidal, Exponential, Rectangular, Triangular. Signal Classification: Finite- Versus Infinite- Duration Signals,Right Sided-, Left Sided- and Both Sided Signals, Continuous Time Continuous Valued- Versus Discrete Time Discrete Valued- Signals, Deterministic- Versus Nondeterministic- Signals, N-Dimensional Versus N-Channel Signals, Periodic- Versus Non-periodic- Signals, Even- Versus Odd- Signals, Power- Versus Energy- Signals,	**04**
	1.2	**Definition of System and System Classification:** System Definition, Representation of Continuous Time System, Discrete Time System System Classification: Discuss one practical example with each system Static- Versus Dynamic- System, Time Invariant- Versus Time Variant- System, Linear Versus Non-linear System, Causal Versus Non-causal System, Stable Versus Unstable System	**03**
02	**2.1**	**Time Domain Linear Time Invariant System (LTI) Analysis:** Analysis of LTI Systems using Convolution Operation, Properties of Convolution, Importance of Impulse Response, Step Response Sufficient and Necessary Condition for Stability, Causality (No Derivation), Impulse Response of Interconnected LTI Systems	**04**
	2.2	Correlation and Spectral Density: Auto-Correlation Function, Cross-Correlation Function, Analogy between Correlation and Convolution Function, Properties of Auto-Correlation, Cross-Correlation (Only Statements, No Derivations)	**03**
	3.1	**Continuous Time Signals & Systems Analysis using Laplace Transform** Definition of Laplace Transform, Need of Laplace Transform, Derivation of Standard Laplace Transform Pairs for Right Sided-, Left Sided-, Both Sided- Signals along with Concept of Region of Convergence, respectively, Properties of Bilateral Laplace Transform (Only Statements, No Derivation), Unilateral	**04**

03		Laplace Transform, Inverse Laplace Transform using Partial Fraction Method - For Simple Poles, Repetitive Poles, Complex Conjugate Poles	
	3.2	LTI System Analysis using Laplace Transform: Concept of Transfer Function, Causality-, Stability- ,Combined Causality & Stability- Condition of systems in Laplace-Domain, Differential Equation, Impulse Response, Step Response	**03**
04	**4.1**	**Discrete Time Signals & Systems Analysis using Z-Transform** Definition of Z-Transform, Need of Z-Transform, Derivation of Standard Z-Transform Pairs for Right Sided-, Left Sided-, Both Sided- Signals along with Concept of Region of Convergence, respectively, Properties of Z-Transform (Only Statements, No Derivation), Unilateral Z-Transform, Inverse Z-Transform using Partial Fraction Method - For Simple Poles, Repetitive Poles, Complex Conjugate Poles	**04**
	4.2	LTI System Analysis using Z-Transform:Systems Characterized by Linear Constant Coefficient Difference Equation, Transfer Function, Pole-Zeros Plot of a System Function , Causality and stability of systems, Total response of a system	**03**
05	**5.1**	**Fourier Analysis of Continuous and Discrete Time Signals and Systems:** Trigonometric Fourier Series, Exponential Fourier Series Representation of Signals, magnitude and phase spectra, power spectral density and bandwidth. Gibbs phenomenon, Properties of Fourier Series (Only Statements, No Derivation)	**03**
	5.2	Fourier transform of periodic and non-periodic functions, Properties of Fourier Transform, Inverse Fourier Transform, Frequency Response: computation of Magnitude and Phase Response Relationship between Laplace Transform and Fourier Transform, Relationship between Z-Transform and Discrete Time Fourier Transform, Mapping between s-Domain and z-Domain	**04**
06	**6.1**	Concept of finite impulse response systems and infinite impulse response systems, Linear Phase FIR systems	**02**
	6.2	Realization structures of LTI system: Direct form –I and direct form II, Linear Phase FIR structures.	**02**
Self- study Topic		Derivation of LTI System to be BIBO Stability Condition, Derivation of Laplace Transform Properties, Derivation of Z-Transform Properties, Derivation of Fourier Transform Properties	

<u>Assessment</u>:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and the second class test when an additional 35% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on the entire syllabus wherein sub- questions of 2 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.(e.g. Suppose Q.2 has part (a) from module3 then part (b) will be from any module other than module 3)
5. In question paper weightage of each module will be proportional to number of respective lecture hrs as mentioned in the syllabus.

Text Books:

1. Nagoor Kani, Signals and Systems, Tata McGraw Hill, Third Edition, 2011.
2. Rodger E Ziemer, William H. Tranter and D. Ronald Fannin, Signals and Systems, Pearson Education, Fourth Edition 2009.
3. Alan V. Oppenhiem, Alan S. Willsky and S. Hamid Nawab, Signals and Systems, Prentice-Hall of India, Second Edition, 2002.
4. Simon Haykin and Barry Van Veen, Signals and Systems, John Wiley and Sons, Second Edition, 2004.

References:

1. B.P. Lathi, Principles of Linear Systems and Signals, Oxford, Second Edition, 2010

NPTEL/ Swayam Course:

1. Course: Principles of Signals & Systems By Prof. Aditya K. Jagannatham (IIT Kanpur); https://swayam.gov.in/nd1_noc20_ee15/preview

Course Code	Course Name	Credits
MTDO501	**Production Processes**	**03**

Prerequisite: MTC303 Engineering Materials and Metallurgy, MTL405 Machine Shop Practice,

Objectives:

1. To familiarize with the various production processes used on shop floors
2. To select appropriate production processes for a specific application.
3. To introduce to the learner various machine tools used for manufacturing
4. To familiarize with principle and working of non-traditional manufacturing
5. To familiarize with electronic manufacturing fundamentals

Outcomes: L**earner will be able to**

1. Demonstrate understanding of casting process
2. Illustrate principles of forming processes.
3. Demonstrate applications of various types of welding processes.
4. Differentiate chip forming processes such as turning, milling, drilling, etc.
5. Illustrate the concept of producing polymer components and ceramic components.
6. Illustrate principles and working of non-traditional and electronic manufacturing

Module	Details	Hrs.
Prereq uisite		--
1	**Introduction to Production Processes and Metal Casting** 1.1. Classification of Production Processes and applications areas 1.2. Pattern making materials, Types of pattern and allowances. 1.3. Sand moulding and Machine moulding 1.4. Gating system :Types of riser, types of gates, solidification 1.5.**Special casting processes** : Shell moulding, Investment casting, Die casting, Vacuum casting, Inspection & casting defects and remedies.	06
2	**Joining Processes** 2.1.Classification of various joining processes; Applicability, advantages and limitations of Adhesive bonding, Mechanical Fastening; Welding and allied processes, Hybrid joining processes. 2.2.Classification and Working of various welding methods: Gas, Arc, Chemical, Radiant, Solid State etc. 2.3.Welding Joints, Welding Positions, Welding defects and their remedies. Robotic Welding.	07
3	**3.1. Forming processes** Introduction and classification of metalworking processes, hot and cold working processes Introduction, forging and rolling operations, Defects in rolled and forged components, Extrusion process, Wire and tube drawing processes. **3.2. Sheet metal working processes** Classification of Sheet metal operations, types of Presses used in sheet metal operations, types of dies.	06
4	**4.1. Machine Tools, Machining Processes**. **Machine Tools and Machining Processes:** Lathe Machines, Milling Machines, Drilling Machines, and Grinding Machines and selection of grinding wheel (Dressing and Truing), Broaching machines, Lapping/Honing machines (Super Finishing Operations) and shaping/slotting/planning Machines. **Gear Manufacturing** Gear milling, standard cutters and limitations, Gear Hobbing, Gear Shaping, Gear Shaving and Gear Grinding processes	10

	4.2. Tool Engineering Geometry and nomenclature of single point cutting tool, Speed, feed, depth of cut, Taylor's tool life equation, Concept of chip formation and types of chips. Introduction to Jigs and Fixtures and types.	
5	**5.1Non Traditional Machining Processes**: Electro-chemical machining (ECM) Electric-discharge machining (EDM) Ultrasonic machining (USM) Laser Beam Machining (LBM) **5.2 Semiconductor IC Manufacturing**: Oxidation, Photolithography, Etching, Doping , Deposition , Process Integration, Packaging. PCB Assembly with SMT Process	06
6.	**6.1 Polymer Processing:** Polymer Molding Techniques for thermoplastic and thermosetting plastics. Applications of Plastics in Engineering field. **6.2 Powder Metallurgy**: Introduction to PM, Powder making processes, Steps in PM. Compaction and Sintering processes. Secondary and finishing operations in PM.	04

Assessment:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 35% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

6. Question paper will comprise of total 06 questions, each carrying 20marks.
7. Total 04 questions need to be solved.
8. Question No: 01 will be compulsory and based on entire syllabus wherein sub-questions of 2 to 5 marks will be asked.
9. Remaining questions will be mixed in nature.(e.g. Suppose Q.2 has part (a) from module3 then part (b) will be from any module other than module 3)
10. In question paper weightage of each module will be proportional to number of respective lecture hrs as mentioned in the syllabus.

Text/Reference Books:

1. Welding technology by O P Khanna
2. Foundry technology by O P Khanna
3. Elements of workshop technology. Vol. 1 & II by S K Hajra Choudhury
4. Manufacturing Science by Ghosh and Malik
5. Production Technology by WAJ Chapman Vol I, II, III
6. Production Technology by P C Sharma.
7. Production Technology by Raghuvanshi.
8. Gary S. May,Costas J. Spanos "Fundamentals Of Semiconductor Manufacturing And Process Control" John Wiley & Sons

Links for online NPTEL/SWAYAM courses:
https://nptel.ac.in/courses/112/107/112107144/
https://nptel.ac.in/courses/112/107/112107145/
https://nptel.ac.in/courses/112/104/112104195/
https://nptel.ac.in/courses/112/107/112107239/
https://nptel.ac.in/courses/112/105/112105126/
https://nptel.ac.in/courses/112/105/112105127/
https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-mm25/
https://nptel.ac.in/courses/112/107/112107078/
https://nptel.ac.in/courses/112/104/112104162/

Course Code	Course Name	Credits
MTDO501	**Operating Systems**	**03**

Prerequisite: MTC302 Data Structures and Algorithms MTL303 Electrical and Electronics Workshop

Objective:

1. To provide an introduction to the internal operation of modern operating systems. major components of Operating System & its functions.
2. To introduce the concept of a process and its management like transition, CPU scheduling, etc
3. To understand basic concepts related to Inter-process Communication (IPC) like mutual exclusion, deadlock, etc. and role of an Operating System in IPC.
4. To Study memory management & implementation of memory management policies, and file systems.
5. To Study RTOS Architecture and its application with different variants
6. To study the need and fundamentals of special-purpose operating system with the advent of new emerging technologies.

Outcomes: Learner will be able to..

1. Understand the basic concepts related to Operating Systems.
2. Describe the process management policies and illustrate scheduling of processes by CPU.
3. Explain and apply Inter-process Communication (IPC) and evaluate deadlock conditions
4. Illustrate the memory & Describe the memory and file management
5. Describe Architecture of RTOS & its Implementation with application
6. Select Appropriate OS for interdisciplinary applications

Module	Details	Hrs.
01	**Introduction to Operating System:** Overview of Operating Systems, Operating System Architecture and Operations; Functions of Operating Systems; Operating System Services and Interface; System Calls and its Types; System Programs; System Boot. **Self-learning Topics:** Study of System calls with examples of any three OS Study of any three System boot examples of different OS. Study of Types of Operating System Structures;	5
02	**Process Management** Basic Concepts of Process; Operation on Process; Context Switching; Process State Model and Transition; Process Control Block; Introduction to Threads; Types of Threads and its models, Basic Concepts of Scheduling; Types of Schedulers; Scheduling Criteria; Scheduling Algorithms. **Self-learning Topics:** Comparison of Process and PCB in different OS (e.g Window, Linux, Mac) Study the comparison between Scheduling Algorithms. Implementation Process scheduling algorithm using C /JAVA Lang	9
03	**Inter Process Communication and Synchronization** Inter-process Communication -Shared Memory & Message Passing; Concurrent Process ,Race Condition; Critical Region and Problem; Peterson's Solution; Synchronization; Semaphores Producer Consumer Problem using semaphore Introduction to Deadlocks; Deadlock Characterization; Deadlock Detection and Recovery; Deadlock Prevention; Deadlock Avoidance.	8

	Self-learning Topics: Study of comparison for Deadlock detection and recovery in different OS Implementation of Banker's Algorithm using C/Java Lang	
04	**Memory Management** Basic Concepts of Memory Management; Swapping; Memory Allocation Algorithms; Paging; Structure of Page Table; Segmentation; Virtual Memory & Demand Paging, Page Replacement Algorithms **Self-learning Topics:** Implement Page Replacement Algorithm using C/Java Lang Implement Memory Allocation Algorithm using C/Java Lang **File Management** Basic Concepts of File System; File Access Methods; Directory Structure; File-System Implementation; Allocation Methods; Free Space Management; Overview of Mass-Storage Structure & Disk Structure; Disk Scheduling Algorithms; Introduction to I/O Systems. **Self-learning Topics:** Implement Disk Scheduling Algorithm using C/Java Lang Study the comparison of different disk space allocation methods.	9
05	**Real Time Operating Systems:** Introduction to RTOS & Architectures Characteristics and Comparison of open source & Proprietary RTOS,Types of RTOS – Real & Soft, Comparison of Traditional OS & RTOS,Applications of RTOS in Robotics , Scheduling Real-time task, Application and Features of MUCOS, VXWORKS operating systems, RTOS in embedded system, Fault tolerant Application and control systems, **Self-learning Topics:** Comparison of Different RTOS Comparison between mucos & Vxworks	5
06	**Case Study:** Open-source and Proprietary Operating System; Real-Time Operating System; Embedded Operating Systems; Cloud and IoT Operating Systems; Mobile Operating System; Automotive operating systems ,ROBOT OS **Self-learning Topics:** Case Study on any one Special-purpose Operating Systems. Study the comparison of Linux & ROBOT OS. Study File systems commands, Process management commands, Memory Management commands, Filters and File permission commands in different operating system	3

Assessment:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 35% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein sub-questions of 2 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.(e.g. Suppose Q.2 has part (a) from module3 then part (b) will be from any module other than module 3)
5. In question paper weightage of each module will be proportional to number of respective lecture hrs as mentioned in the syllabus.

Text Books:

1. A. Silberschatz, P. Galvin, G. Gagne, Operating System Concepts, 10th ed., Wiley, 2018.
2. W. Stallings, Operating Systems: Internal and Design Principles, 9th ed., Pearson, 2018.
3. A. Tanenbaum, Modern Operating Systems, Pearson, 4th ed., 2015.
4. Rajkamal " Embedded Systems" TMH Publication

Reference Books:

1. N. Chauhan, Principles of Operating Systems, 1st ed., Oxford University Press, 2014.
2. A. Tanenbaum and A. Woodhull, Operating System Design and Implementation, 3rd ed., Pearson.
3. R. Arpaci-Dusseau and A. Arpaci-Dusseau, Operating Systems: Three Easy Pieces, CreateSpace Independent Publishing Platform, 1st ed., 2018
4. Dr.K.V.K.K. Prasad " Embedded Real time systems"
5. Maurice J. Bach, "The Design of Unix Operating System", Prentine Hall

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/noc/courses/noc16/SEM2/noc16-cs10/
https://nptel.ac.in/courses/106/102/106102132/
https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-cs51/

Course Code	Course Name	Credits
MTPBL301	**Mini Project-2A**	**02**

Objectives

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To familiarize the process of solving the problem in a group.
3. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4. To inculcate the process of self-learning and research.

Outcome: Learner will be able to…

1. Identify problems based on societal /research needs.
2. Apply Knowledge and skill to solve societal problems in a group.
3. Develop interpersonal skills to work as member of a group or leader.
4. Draw the proper inferences from available results through theoretical/ experimental/simulations.
5. Analyse the impact of solutions in societal and environmental context for sustainable development.
6. Use standard norms of engineering practices
7. Excel in written and oral communication.
8. Demonstrate capabilities of self-learning in a group, which leads to life long learning.
9. Demonstrate project management principles during project work.

Guidelines for Mini Project

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in two semesters by all the groups of the students. i.e. Mini Project 1 in semester III and IV. Similarly, Mini Project 2 in semesters V and VI.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of

the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;
    - Marks awarded by guide/supervisor based on log book : 10
    - Marks awarded by review committee : 10
    - Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
    - First shall be for finalisation of problem
    - Second shall be on finalisation of proposed solution of problem.
- In second semester expected work shall be procurement of component's/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
    - First review is based on readiness of building working prototype to be conducted.
    - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including,
    - Identification of need/problem
    - Proposed final solution
    - Procurement of components/systems
    - Building prototype and testing
- Two reviews will be conducted for continuous assessment,
    - First shall be for finalisation of problem and proposed solution
    - Second shall be for implementation and testing of solution.

Assessment criteria of Mini Project

Mini Project shall be assessed based on following criteria;

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness
8. Cost effectiveness and Societal impact

9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

- In **one year, project**, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of **half year project** all criteria's in generic may be considered for evaluation of performance of students in mini project.

Guidelines for Assessment of Mini Project Practical/Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organisations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Mini Project shall be assessed based on following points;

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact
4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms
7. Contribution of an individual's as member or leader
8. Clarity in written and oral communication