AC 29/5/2015
Item No. – 4.45

UNIVERSITY OF MUMBAI

Bachelor of Engineering

Mechatronics Engineering

(Second Year – Sem. III & IV, Third Year- Sem V & VI, and Final Year- Sem VII & VIII)

New course (N- 2015) from Academic Year 2015 -16, 2016-17, and 2017-18 respectively

Under

FACULTY OF TECHNOLOGY

(As per Credit Based Semester and Grading System)

Deans 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 Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved to introduce innovative undergraduate program in Mechatronics Engineering along with course objectives and outcomes to be clearly defined. I am happy to state that, the syllabus committee of mechatronics engineering has adhered to the resolutions passed by Faculty of Technology, and developed curriculum accordingly. In addition to outcome based education, credit based semester and grading system is also introduced to ensure quality of engineering education.

Credit based semester and grading system enables a much-required shift in focus from teacher-centric to learner-centric education. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes and Faculty of Technology has devised a transparent credit assignment policy and adopted ten points scale to grade learner's performance. The program of Mechatronics Engineering is introduced from the academic year 2014-2015.

Dr. S. K. Ukarande
Dean,
Faculty of Technology,
Member - Management Council, Senate, Academic Council
University of Mumbai, Mumbai

Chairman Preamble

Engineering education in India is expanding and is set to increase manifold. The major challenge in the current scenario is to ensure quality to the stakeholders along with expansion. Furthermore, to achieve the broad horizon of technology system development, the innovative program consisting of interdisciplinary approach is today's need. Considering this requirement and recent thrust in technology, the innovative undergraduate program in Mechatronics Engineering is introduced first time in the University of Mumbai.

To ensure quality in higher education accreditation of program is essential. The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program outcomes are essentially a range of skills and knowledge that a student will have at the time of graduation from the program. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating the philosophy of outcome based education in the process of curriculum development.

As the Chairman, Board of Studies in Mechanical Engineering of University of the Mumbai, I am happy to state here that, the Program Educational Objectives of this innovative program were finalized in a brain storming session, which was attended by more than 20 senior faculty members from different affiliated Institutes of the University from the various disciplines such as Mechanical, Electrical, Electronics, and Computer Engineering. The Program Educational Objectives finalized for the undergraduate program in Mechatronics Engineering are listed below;

1. To prepare the Learner in building technology systems through the interdisciplinary approach.
2. To prepare the Learner to use modern tools embedding different disciplines of engineering in order to solve real life problems.
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.

In addition to Program Educational Objectives, for each course of undergraduate program, objectives and expected outcomes are also included in the curriculum. I strongly believe that even a small step taken in the right direction will definitely help in providing quality education to the major stake holders.

Dr. S. M. Khot

Chairman, Board of Studies in Mechanical Engineering, University of Mumbai

Program Structure for B E Mechatronics Engineering

T. E. Mechatronics -(Semester V)

Subject Code	Subject Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
MTC501	Manufacturing Processes	4	--	4	--	4
MTC502	Machine Design	4	--	4	--	4
MTC503	Sensors and Actuators	4	--	4	--	4
MTC504	Control Systems	4	--	4	--	4
MTC505	Embedded Systems	4	--	4	--	4
MTC506	Operating Systems	2	--	2	--	2
MTL507	Business Communication and Ethics &	--	2*+2	--	2	2
MTL508	Machine Design Laboratory	--	2	--	1	1
MTL509	Sensors and Actuators Laboratory	--	2	--	1	1
MTL510	Control Systems Laboratory	--	2	--	1	1
MTL511	Embedded Systems Laboratory	--	2	--	1	1
Total		**22**	**12**	**22**	**6**	**28**

Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract. /oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test1	Test 2	Avg.					
MTC501	Manufacturing Processes	20	20	20	80	03	--	--	100
MTC502	Machine Design	20	20	20	80	03	--	--	100
MTC503	Sensors and Actuators	20	20	20	80	03	--	--	100
MTC504	Control Systems	20	20	20	80	03	--	--	100
MTC505	Embedded Systems	20	20	20	80	03	--	--	100
MTC506	Operating Systems	10	10	10	40	02	--	--	50
MTL507	Business Communication and Ethics &	--	--	--	--	--	50	--	50
MTL508	Machine Design Laboratory	--	--	--	--	--	25	--	25
MTL509	Sensors and Actuators Laboratory	--	--	--	--	--	25	25	50
MTL510	Control Systems Laboratory	--	--	--	--	--	25	25	50
MTL511	Embedded Systems Laboratory	--	--	--	--	--	25	25	50
Total		**--**	**--**	**110**	**440**	**--**	**150**	**75**	**775**

*** Theory for entire class to be conducted, & Common for all Engineering Program**

T. E. Mechatronics -(Semester VI)

Subject Code	Subject Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
MTC601	CNC Technology	4	--	4	--	4
MTC602	Metrology and Quality Engineering	4	--	4	--	4
MTC603	Dynamics of Machinery	4	--	4	--	4
MTC604	Power Electronics and Drives	4	--	4	--	4
MTC605	Instrumentation and Control	4	--	4	--	4
MTC606	Applied Hydraulics and Pneumatics	4	--	4	--	4
MTL607	CNC Technology Laboratory	--	2	--	1	1
MTL608	Metrology and Quality Engineering Laboratory	--	2	--	1	1
MTL609	Instrumentation and Control Laboratory	--	2	--	1	1
MTL610	Applied Hydraulics and Pneumatics Laboratory	--	2	--	1	1
Total		**24**	**8**	**24**	**4**	**28**

Subject Code	Subject Name	Examination Scheme							
		Theory							
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)	Term Work	Pract. /oral	Total
		Test1	Test 2	Avg.					
MTC601	CNC Technology	20	20	20	80	03			100
MTC602	Metrology and Quality Engineering	20	20	20	80	03			100
MTC603	Dynamics of Machinery	20	20	20	80	03	--	--	100
MTC604	Power Electronics and Drives	20	20	20	80	03	--	--	100
MTC605	Instrumentation and Control	20	20	20	80	03			100
MTC606	Applied Hydraulics and Pneumatics	20	20	20	80	03			100
MTL607	CNC Technology Laboratory	--	--	--	--	--	25	25	50
MTL608	Metrology and Quality Engineering Laboratory	--	--	--	--	--	25	--	25
MTL609	Instrumentation and Control Laboratory	--	--	--	--	--	25	25	50
MTL610	Applied Hydraulics and Pneumatics Laboratory	--	--	--	--	--	25	25	50
Total		**--**	**--**	**120**	**480**	**--**	**100**	**75**	**775**

CLASS: TE (Mechatronics)	Subject Code: MTC501	Semester:-V
SUBJECT: **Manufacturing Processes**		Credit-4

Periods per week: 1Period of 60 min.	Lecture	4	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory Examination	3	80
	Internal Assessment		20
	TOTAL		**100**

Pre-requisite:

1. FEL 101 Basic Workshop Practice-I
2. FEL 201 Basic Workshop Practice-II

Objectives:

1. To prepare the students understand basic manufacturing processes used in industries.
2. To make the students understand various hot and cold working processes and sheet metal forming methods and its applications.
3. To prepare the students understand various machine tools and basic machining processes as well as understand the fundamentals of metal cutting.
4. To familiarize the students with IC and PCB fabrication techniques.

Outcomes: Learner should be able to…

1. Distinguish between the conventional and modern machine tools as well as various methods of machining processes.
2. Illustrate unconventional machining processes and various applications.
3. Illustrate various Rapid prototyping techniques as well additive manufacturing practices such as 3D printing.
4. Illustrate various methods of electronics component fabrication.

Modules	Details	Hrs.
01	**1.1 Manufacturing:** Definition, classification of manufacturing processes. **1.2 Casting:** Introduction to casting, patterns, types, pattern materials, allowances. Molding types, molding sand, gating and risering, Cores & Core making. Special Casting Process- Shell, Investment, Die casting, Centrifugal Casting. **1.3 Shaping Processes for Plastics:** Extrusion, injection molding, blow molding, rotational molding, thermoforming, compression and transfer molding.	**07**
02	**2.1 Hot and Cold Working -** Rolling, Forging, Wire Drawing, Extrusion- types- Forward, backward and tube extrusion**.** **2.2 Sheet Metal Operations -** Blanking- blank size calculation, drawing, draw ratio, drawing force, Piercing, Punching, Trimming, Stretch forming, Shearing, Bending- simple problems- Bending force calculation, Tube forming - Embossing and coining, Types of dies: Progressive, compound and combination dies.	**08**
03	**3.1 Theory of Metal Cutting:** Definition of machining, orthogonal and oblique cutting, mechanics of orthogonal cutting - Shear angle and its significance, types of chips- Simple problems on machining mechanics. Classification of cutting tools - single, multipoint. Tool Nomenclature, cutting tool materials, Tool wear and tool life, machinability, cutting fluids.	**12**

	3.2 Machine Tools (Construction and Operations): Lathe machine, shaping, planning and slotting machine. Milling machine – classification, types of cutters, Indexing methods- Simple problems. Drilling and boring machine. Gear cutting machines- classification. Grinding machines – classification.	
04	**4.1 Welding:** Arc welding, resistance welding, oxyfuel gas welding, forge welding, friction stir welding and ultrasonic welding. **4.2 Brazing:** types of brazed joints, brazing methods. **4.3 Soldering and Adhesive Bonding:** Joint designs in soldering, solders and fluxes, soldering methods. Adhesive joint designs, adhesive types, adhesive application technology, advantages and limitations.	**07**
05	**5.1 Unconventional machining processes:** classification according to type of energy used for machining, basic principles, machines and applications of, Electrical discharge machining (EDM), Electron beam machining (EBM) , Plasma arc machining (PAM), Laser beam machining (LBM), Electrochemical machining (ECM), Chemical machining (CHM), Ultrasonic machining (USM). **5.2 Additive Manufacturing:** Fundamentals of rapid prototyping, stereo lithography, laminated object manufacturing, fused deposition modeling, 3D printing, selective laser sintering.	**10**
06	**6.1 Processing of Integrated Circuits:** processing sequence, silicon processing, photolithography, layer processes used in IC fabrication, IC packaging. **6.2 Electronic assembly and packaging:** PCB structure, types and materials. Processes used in PCB fabrication, PCB assembly.	**08**

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 total six questions.
2. Each question will be of 20 marks.
3. Question one will be compulsory and based on maximum part of syllabus.
4. Remaining questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
5. Only four question 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.

References:

1. *Elements of Workshop Technology (Volume -1 & 2)* by S. K. Hajra Choudhary, A. K. Hajra Choudhary, Nirjhar Roy, Media promoters (2010).
2. *A Course in Workshop Technology (Vol. I & II)* by B. S. Raghuwanshi, Dhanpat Rai & CO. (2001).
3. *Workshop Technology Part 1, 2 and 3.* By W. A. J. Chapman, Taylor & Francis (1972).
4. *Production Technology – HMT*, Tata McGraw-Hill (1980).
5. *Manufacturing, Engineering and Technology, 4th Edition*, by Serope Kalpakjian, Steven R. Schmid, published by Pearson (2005).
6. *Fundamentals of Modern Manufacturing- Materials, Processes and Systems, 3rd Edition* by Mikell P. Groover, Wiley India (2002).
7. *Manufacturing Processes for Engineering Materials, 4th Edition,* by Serope Kalpakjian, Steven R. Schmid, published by Pearson (2007).

CLASS: TE (Mechatronics)	Subject Code: MTC502		Semester:-V
SUBJECT: **Machine Design**			Credit-4
Periods per week: 1Period of 60 min.	Lecture	4	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory Examination	3	80
	Internal Assessment		20
	TOTAL		**100**

Pre-requisite:

1. MTL306 Computer Aided Machine Drawing Laboratory
2. MTL309 Engineering Materials and Metallurgy Laboratory
3. MTC 404 Strength of Materials

Objectives:

1. To study basic principles of machine design
2. To acquaint with concepts of stress and strength related to various components.
3. To familiarize with use of design data books and various codes of practice.
4. To make conversant with preparation of working drawings based on design.

Outcomes: Learner will able to…

1. Demonstrate understanding of various design considerations.
2. Apply basic principles of machine design
3. Design machine elements on the basis of strength and standardization.
4. Use design data books and various standard codes of practices.
5. Acquire skill in preparing production drawings of various components designed.

Module	Details	Hrs
1	**Design Considerations** Mechanical Engineering Design, Design methods, Aesthetic and Ergonomics consideration in design. Material properties and their uses in design. Manufacturing consideration in design: tolerances, types of fits, selection of fits. Design considerations of casting and forging. Basic principles of Machine Design, Standards, I. S. codes, Preferred Series and numbers. Theories of failures, Factor of safety. Variable Stresses, Fatigue Cycle and Failures, Endurance Limit, Soderberg and Goodman Design Criteria. Systems layout; their free body diagrams. Force estimation on individual elements.	12
2	**Joints:** Cotter Joint, Knuckle Joint, Turn Buckle, Bolted and welded joints for direct and eccentric loading.	09
3	**Springs;** Design of Helical Springs under static and variable axial loading, Design of Leaf Springs.	07
4	**Shafts and Couplings:** Design of shafts for power transmission under static and fatigue criteria, Types of keys and suitability on shafting conditions. Classification of Couplings, Design of split muff, flange, bushed pin type Couplings.	10

5	**Bearings:** Design of Hydro dynamically lubricated bearings (Self Contained), Selection of rolling contact bearings based on various loading and speed conditions. Mechanical Seals (Types and Selection)	08
6	**Flywheels:** Crankshaft torque, Turning moment diagrams, fluctuation of Energy, Design of Flywheels for IC Engines and punching presses.	06

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 examinations:

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.

Note: Use of standard design data books like PSG Data Book, Design Data Book by Mahadevan & Reddy is permitted at the examination and shall be supplied by the college.

References:

1. Design of machine elements -- V. B. Bhandari. Tara Mc-Graw Hill Pub.
2. Design of machine elements -- Sharma,Purohil. Prentice Hall India Pub.
3. Machine Design - An Integrated Approach -- Robert L. Norton – PearsonEducation.
4. Machine Design - Pandya & Shah- Charotar PI/blishing.
5. Mechanical Engineering Design - J. E. Shigley - McGraw Hill
6. Recommended Data Books - PSG, K. Mahadevan
7. Machine Design - Reshetov - Mir Publication
8. Machine Design - Black Adams-Mcgraw Hill
9. Fundamentals of Machine Elements - Hawrock, Jacobson Mcgraw Hill
10. Machine Design - Patel, Pandya, Sikh, Vol. - I & II, C. Jamnadas& Co. Educational & Law Publishers
11. Design of Machine Elements - V.M. Faires
12. Design of Machine Elements - Spotts.

CLASS: TE (Mechatronics)	Subject Code: MTC503		Semester:-V
SUBJECT: **Sensors and Actuators**			Credit-4
Periods per week: 1Period of 60 min.	Lecture	4	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory Examination	3	80
	Internal Assessment		20
	TOTAL		**100**

Pre-requisite:

1. MTC305 Applied Electrical and Electronics Engineering
2. MTC406 Signals and Systems

Objectives:

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

Outcomes: Learner will be able to…

1. Understand how different physical variables are measured and illustrate their working principles
2. Identify and select proper sensors for specific applications
3. Understand issues of implementation of different sensors including calibration and error analysis
4. Understand different types of actuators and their implementation

Module	Detailed Contents	Hrs.
01	Significance of Sensor Measurements, Classification of Sensors, Analog vs Digital Sensors **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. Selection criteria of sensors for mechatronic systems	10
02	**Displacement Measurement:** Transducers for displacement, displacement measurement, potentiometer, LVDT, Capacitance Types, Digital Transducers (optical encoder), **Strain Measurement:** Theory of Strain Gauges, gauge factor, temperature Compensation, Wheatstone Bridge circuit, orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors **Measurement of Angular Velocity**: Tachometers, Digital tachometers and Stroboscopic Methods. **Acceleration Measurement**, theory of accelerometer and vibrometers, practical accelerometers, strain gauge based and piezoelectric accelerometers.	08
03	**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, Hall Effect Sensors, 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 behavior, Heat dissipation in DC motor, Velocity Profile Optimization, Inertia matching, Servo Amplifier, DC motor drive. **Stepper Motors:** Characteristics of a Stepper motor, Classification of a Stepper motor, Principle of Operation, Step Angle, Electrical model of energized coil, Drive method, Stepper motor performance **Induction motors:** Three phase motor, induction motor characteristics **Linear Actuators:** Voice Coil Actuators, solenoids	10
05	**Pneumatic and Hydraulic actuating systems** Components of pneumatic and hydraulic systems, pumps, compressor, filter, control valves, pressure regulation, relief valves, accumulator. **Harmonic drive, Comb drive.** **Smart Material Actuators:** Piezoelectric transducers, Electroactive polymers, Shape Memory alloys, Artificial Muscle materials	09
06	**Consideration during with actuator selection:** Actuator bandwidth and frequency response, actuator range, power and energy considerations, tradeoffs between force/displacement or torque/speed, control systems and electronics, industrial considerations	07

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.

References:

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. Mechanical Engineering Measurement - Thomas Beckwith, N.Lewis Buck, Roy Marangoni - *Narosa Publishing House, Bombay.*
5. Mechanical Engineering Measurements - A. K. Sawhney – *DhanpatRai & Sons, New Delhi.*
6. Instrumentation Devices & Systems - C.S. Rangan & G.R.Sarrna - *Tata McGraw Hill.*
7. Instrumentation & Mechanical Measurements - A.K. Thayal.
8. Optomechatronics: Fusion of Optical and Mechatronics Engineering By Hyungsuck Cho
9. Smart Structures: Analysis and Design, AV Shrinivasan and D Micheal Macfarland. Cambridge University Press
10. Smart Materials and Structures: MV Gandhi and BS Thomson. Chapman and Hall

CLASS: TE (Mechatronics)	Subject Code: MTC504		Semester:-V
SUBJECT: **Control Systems**			Credit-4
Periods per week: 1Period of 60 min.	Lecture	4	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory Examination	3	80
	Internal Assessment		20
	TOTAL		**100**

Pre-requisite:

1. MTC402 Kinematics of Machinery
2. MTC305 Applied Electrical and Electronics Engineering

Objectives:

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

Outcomes: Learner will be able to..

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

Module	Detailed contents	Hrs.
1. 0	**Introduction to Control System and components**	10
	Introduction to basic terms, classifications & types of Control Systems, Block diagrams & Signal flow graphs; Transfer function- determination of transfer function using block diagram reduction techniques. Determination of transfer functions of thermal, fluid, and mechanical spring-mass-damper system. Mason's Rule, Signal-Flow Graphs of State Equations.	
2.0	**Time –Domain Analysis and Response**	10
	Modeling in the Time Domain: General State-Space Representation, Applying the State-Space Representation, Converting a Transfer Function to State Space, Converting from State Space to a Transfer Function.	
	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.	
3.0	**Root Locus Method**	07
	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.	

4.0	**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.	10
5.0	**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	09
6.0	**Analog and Digital Control** **Analog and Digital Control:** Introduction to Digital control systems, comparison with analog control systems, Case study of analog control system design with practical approach- Temperature Control system. Implementation of Digital controller in- Temperature Control System and Digital Power Supply, Digital Signal controller based Implementation technique.	06
		52

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.

References:

1. Norman S. Nise, "*Control System Engineering*", John Wiley & Sons, Inc, Sixth Edition
2. B. C. Kuo, "Automatic Control System", Prentice Hall of India, Seventh edition, 2001.
3. Nagraath Gopal "Control Systems Engineering -Principles and Design" New Age Publishers
4. M. Gopal, "Modern Control System Theory", Wiley Eastern Ltd., New Delhi.
5. K. Ogata, "Modern Control Engineering", 3 ed. Prentice Hall of India (P) Ltd., New Delhi.
6. Dr. K.P. Mohandas, "Modern Control Engineering", revised edition, Sanguine Publishers, Bangalore, 2006.

CLASS: TE (Mechatronics)	Subject Code: MTC505		Semester:-V
SUBJECT: **Embedded Systems**			Credit-4
Periods per week: 1Period of 60 min.	Lecture	4	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory Examination	3	80
	Internal Assessment		20
	TOTAL		**100**

Pre-requisite:

1. MTC304: Digital Electronics
2. MTC305: Applied Electrical and Electronics Engineering
3. MTC405: 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 architecture, interface peripherals and program 8051 microcontrollers.
2. Describe architecture, interface peripherals and program ARM7 microcontrollers
3. Illustrate the basic terminologies of software development and real time operating system.
4. Design microcontroller based embedded systems for various applications

Module	Detailed contents	Hrs.
1. 0	**General Concepts** 1.1 **Basic Concepts:** Microprocessor and Microcontroller, Von Neumman and Harward, Intel 8085 microprocessor architecture (only) 1.2 **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	4
2.0	**8051 Microcontroller** 2.1 **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 2.2 **8051 Assembly Language Programming:** Instruction set, Addressing mode, Assembler directives and programs 2.3 **8051 Interfacing:** LED, LCD, seven segment display, keyboard, ADC, DAC, Stepper Motor, Relay and Serial Communication	12
3.0	**ARM7: A 32-bit Microcontroller** 3.1 **Architecture:** Features of ARM Microcontroller, Operating modes, Architecture, Registers, CPSR, Pipeline, Exceptions, interrupt vector table, memory management, ARM7 processor families 3.2 **ARM7 Programming:** Instruction set, Addressing mode and programs	12
4.0	**Embedded Software Development** 4.1 Assemblers, linkers and loaders. Binary file formats for processor executable files. Typical structure of timer-interrupt driven programs. GNU-GCC compiler introduction, programming with Linux environment and gnu debugging, gnu insight with step level trace debugging, make file interaction, building and execution. 4.2 **Embedded C-programming concepts**: Optimizing for Speed/Memory needs, Interrupt service routines, macros, functions, modifiers, data types, device drivers	08

5.0	**Real Time Operating System** 5.1 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, Message Mailbox Management, Message Queue Management, Memory Management, RTOS implementation. 5.2 Example of OSs for embedded systems - RT Linux.	08
6.0	**Low power hardware design and applications of Embedded Systems** 6.1 **MSP 430**: Features, architecture and programming 6.2 **Case Studies:** -Consumer and Home - Industrial and Automation - Medical - Robotics - Security and communication - Image processing	08
		52

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.

References:

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

CLASS: TE (Mechatronics)	Subject Code: MTC506		Semester:-V
SUBJECT: **Operating System**			Credit-2
Periods per week: 1Period of 60 min.	Lecture	2	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory Examination	2	40
	Internal Assessment		10
	TOTAL		**50**

Prerequisite:

1. Basic Computer Hardware Knowledge

Objective:

1. To provide an introduction to the internal operation of modern operating systems.
2. To Study processes and CPU scheduling, memory management, and file systems.

Outcomes: Learner will be able to..

1. Illustrate the role of OS
2. Differentiate between OSs and their features
3. Illustrate the memory, IO, process and file management

Module	Topics	Hrs.
1. 0	**Introduction to Operating System:** Overview of operating systems, functionalities and characteristics of OS Hardware concepts related to OS, Difference between 32-bit and 64 –bit operating system. CPU states, I/O channels, microprogramming	2
3.0	**Process Management and Memory Management:** The concept of a process, operations on processes, process states, concurrent processes, process control block, process context. Use of threads and Processes in Operating Systems and difference between them. UNIX process control and management, PCB, signals, forks and pipes. Interrupt processing, operating system organization, OS kernel FLIH, dispatcher. Concurrency, Context switching, Synchronization and Race condition in Operating System. Interprocess Communication, Usage of semaphores, Classic Syncronization Problems, Alternative to semaphores. CPU scheduling, goal of CPU scheduling, Difference between pre-emptive and non-preemptive scheduling. CPU scheduling algorithm. Concepts of deadlock prevention and avoidance, detection and recovery. Memory hierarchy, Interaction of Operating System with Memory, working of Virtual Memory, three algorithms of dynamic memory allocation. Methods of memory access. Paging and Page replacement algorithm. Concept of segmentation	10
4.0	**File Management:** File organization: blocking and buffering, file descriptor, directory structure. File and Directory structures, blocks and fragments, directory tree, inodes, file descriptors, UNIX file structure. Concept of I/O management	6
5.0	**Real time operating systems :** Introduction, Scheduling Real-time task, thread and Process, Introduction to mucos and Vxworks operating systems, features of operating systems, applications of operating systems, embedded system, VoIP, Fault tolerant Application and control systems, Comparison between mucos & Vxworks	5

6.0	**Case Study:** UNIX/Linux OS: Commands Related to Shell, File systems, Process management, Memory Management, Filters and File permission	3
		26

Internal Assessment:

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

References:

1. Maurice J. Bach, “The Design of Unix Operating System”, Prentine Hall
2. Silberschatz A., Galvin P., and Gagne G, “Operating Systems Concepts”, VIIIth Edition Wiley.
3. Tanenbaum, “Modern Operating Systems”, IIIrd Edition, PHI
4. William Stallings, “Operating System-Internal & Design Principles”, VIth Edition, , Pearson
5. Rajkamal “ Embedded Systems” TMH Publication
6. Dr.K.V.K.K. Prasad “ Embedded Real time systems”

CLASS: TE (Mechatronics)	Subject Code: MTL507	Semester:-V
SUBJECT: **Business Communication & Ethics**[&]		Credit: 2
*Theory for entire class to be conducted	*Theory	--
Practical to be conducted for batch of students	Practical	*02 hours Theory for entire class per week + 02 hours practicals per batch per week

[&] **Common with All Engineering Programs**

Pre-requisite:

1. FEC206 Communication Skill

Objectives:

1. To inculcate in students professional and ethical attitude, effective communication skills, teamwork, skills, multidisciplinary approach and an ability to understand engineer's social responsibilities.
2. To provide students with an academic environment where they will be aware of the excellence, leadership and lifelong learning needed for a successful professional career.
3. To inculcate professional ethics and codes of professional practice.
4. To prepare students for successful careers that meets the global Industrial and Corporate requirement. Provide an environment for students to work on multidisciplinary projects as part of different teams to enhance their team building capabilities like leadership, motivation, teamwork etc.

Outcomes: A learner will be able to …..

1. communicate effectively in both verbal and written form and demonstrate knowledge of professional and ethical responsibilities
2. Participate and succeed in Campus placements and competitive examinations like GATE, CET.
3. Possess entrepreneurial approach and ability for life-long learning.
4. Have education necessary for understanding the impact of engineering solutions on Society and demonstrate awareness of contemporary issues.

Module	Unit No.	Topics	Hrs
1.0	**1.0**	**Report Writing**	**07**
	1.1	Objectives of report writing	
	1.2	Language and Style in a report	
	1.3	Types of reports	
	1.4	Formats of reports: Memo, letter, project and survey based	
2.0	**2.0**	**Technical Proposals**	**02**
	2.1	Objective of technical proposals	
	2.2	Parts of proposal	
3.0	**3.0**	**Introduction to Interpersonal Skills**	**07**
	3.1	Emotional Intelligence	
	3.2	Leadership	
	3.3	Team Building	
	3.4	Assertiveness	
	3.5	Conflict Resolution	
	3.6	Negotiation Skills	
	3.7	Motivation	
	3.8	Time Management	

4.0	**4.0**	**Meetings and Documentation**	**02**
	4.1	Strategies for conducting effective meetings	
	4.2	Notice	
	4.3	Agenda	
	4.4	Minutes of the meeting	
5.0	**5.0**	**Introduction to Corporate Ethics and etiquettes**	**02**
	5.1	Business Meeting etiquettes, Interview etiquettes, Professional and work etiquettes, Social skills.	
	5.2	Greetings and Art of Conversation	
	5.3	Dressing and Grooming	
	5.4	Dinning etiquette	
	5.5	Ethical codes of conduct in business and corporate activities (Personal ethics, conflicting values, choosing a moral response, the process of making ethical decisions)	
6.0	**6.0**	**Employment Skills**	**06**
	6.1	Cover letter	
	6.2	Resume	
	6.3	Group Discussion	
	6.4	Presentation Skills	
	6.5	Interview Skills	
		Total	**26**

List of Assignments:

1. Report Writing (Synopsis or the first draft of the Report)
2. Technical Proposal (Group activity, document of the proposal)
3. Interpersonal Skills (Group activity and Role play)
4. Interpersonal Skills (Documentation in the form of soft copy or hard copy)
5. Meetings and Documentation (Notice, Agenda, Minutes of Mock Meetings)
6. Corporate ethics and etiquettes (Case study, Role play)
7. Cover Letter and Resume
8. Printout of the PowerPoint presentation

Term Work:

Term work shall consist of all assignments from the list.

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

- Assignments: **20 marks**
- Project Report Presentation**:** **15 marks**
- Group Discussion**:** **10 marks**
- Attendance: **05 marks**

The final certification and acceptance of term work ensures the satisfactory performance of work assigned and minimum passing in the term work.

References:

1. Fred Luthans, "*Organizational Behavior"* , Mc Graw Hill, edition
2. Lesiker and Petit, "*Report Writing for Business"* , Mc Graw Hill, edition
3. Huckin and Olsen, "*Technical Writing and Professional Communication"*, McGraw Hill
4. Wallace and Masters, "*Personal Development for Life and Work"* , Thomson Learning, 12th edition
5. Heta Murphy, "*Effective Business Communication"* , Mc Graw Hill, edition
6. R.C Sharma and Krishna Mohan, "*Business Correspondence and Report Writing"*,
7. B N Ghosh, "*Managing Soft Skills for Personality Development*", Tata McGraw Hill. Lehman,
8. Dufrene, Sinha, "*BCOM*", Cengage Learning, 2nd edition
9. Bell . Smith, "Management Communication" Wiley India Edition,3rd edition.
10. Dr. K. Alex ,"Soft Skills", S Chand and Company
11. Dr. K. Alex,"SoftSkills",S Chand and Company
12. R. Subramaniam, "Professional Ethics" Oxford University Press 2013.

CLASS: TE (Mechatronics)	Subject Code: MTL508	Semester:-V
SUBJECT: **Machine Design Laboratory**		Credit: 1
Practical to be conducted for batch of students	Practical	02 hours per week

Pre-requisite:

1. MTL306 Computer Aided Machine Drawing Laboratory
2. MTL309 Engineering Materials and Metallurgy Laboratory
3. MTC 404 Strength of Materials

Objectives:

1. To study basic principles of machine design
2. To acquaint with concepts of stress and strength related to various components.
3. To familiarize with use of design data books and various codes of practice.
4. To make conversant with preparation of working drawings based on design.

Outcomes: Learner will able to…

1. Demonstrate understanding of various design considerations.
2. Apply basic principles of machine design
3. Design machine elements on the basis of strength and standardization.
4. Use design data books and various standard codes of practices.
5. Acquire skill in preparing production drawings of various components designed.

List of Design exercises:

Design exercises in the form of design calculations with sketches and or drawings on following machine system

1. Cotter joint / Knuckle joint / Turn buckle
2. Coil spring, leaf spring
3. Shafts
4. Couplings
5. Bearings
6. Flywheel

Term Work:

Term work shall consist of

A. Above 6 design exercises
B. Minimum 3 design exercises from the list which may include computer aided drawing on A3 size sheets
C. Stress analysis of any machine element mentioned in the syllabus using any application software and programming language

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

1. Part A : 10 marks
2. Part B : 10 marks
3. Part C : 05 marks

The final certification and acceptance of term work ensures the satisfactory performance of Design and drawing work and minimum passing in the term work.

CLASS: TE (Mechatronics)	Subject Code: MTL509	Semester:-V
SUBJECT: **Sensors and Actuators Laboratory**		Credit: 1
Practical to be conducted for batch of students	Practical	Slot of 02 hours per week

Pre-requisite:

1. MTC305 Applied Electrical and Electronics Engineering
2. MTC406 Signals and Systems

Objectives:

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

Outcomes: Learner will be able to…

1. Illustrate how different physical variables are measured and illustrate their working principles
2. Identify and select proper sensors for specific applications
3. Illustrate issues of implementation of different sensors including calibration and error analysis
4. Demonstrate different types of actuators and their implementation

Expt. No.	List of the Experiment
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
02	Experimental characterization of DC motor
03	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 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.

Distribution of marks for Term work shall be as follows:

Laboratory work (experiments) : 20 marks

Attendance (practical's) : 05 marks

Practical and Oral Examination:

Practical examination of 2 hours duration based on any one of the experiments mentioned in the list above. Oral exam will be on entire syllabus.

Marks distribution: 25 Marks = Practical examination (15 Marks) + Oral examination (10 Marks).

CLASS: TE (Mechatronics)	Subject Code: MTL510	Semester:-V
SUBJECT: **Control Systems Laboratory**		Credit: 1
Practical to be conducted for batch of students	Practical	Slot of 02 hours per week

Pre-requisite:

1. MTC 504 Control Systems.

Objectives:

1. To study the time response of first and second order system
2. To study the error analysis of different control system
3. To study the compensation technique used to stabilize the system

Outcomes: Learner will be able to...

1. Define the open loop and closed loop system
2. Design time response of first and second order system.
3. Simulate the control system for getting different response analysis.
4. Design a compensator to make and stabilize the unstable system.

List of experiments:

1. Experiment on components of control system
2. Transient response of 1^{st} order & 2^{nd} order system
3. Frequency response of 1^{st} order & 2^{nd} order system
4. Steady state error analysis of different types of systems
5. D.C. servomotor and A. C. servomotor
6. Synchro Transmitter and receiver
7. Simulation of block diagram
8. Simulation of Time response analysis
9. Simulation of Frequency response analysis
10. Simulation for Stability analysis

Term Work:

Term work shall consist of 10 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): 20 marks

Attendance (Practicals): 05 marks

Practical and Oral Examination:

Practical examination of 2 hours duration based on any one of the experiments mentioned in the list above. Oral exam will be on entire syllabus.

Marks distribution: 25 Marks = Practical examination (15 Marks) + Oral examination (10 Marks).

CLASS: TE (Mechatronics)	Subject Code: MTL511	Semester:-V
SUBJECT: **Embedded Systems Laboratory**		Credit: 1
Practical to be conducted for batch of students	Practical	Slot of 02 hours per week

Pre-requisite:

1. MTC305 Applied Electrical and Electronics Engineering
2. MTC406 Signals and Systems
3. MTL407 Applied Electronics Laboratory-II
4. MTC405 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 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): 20 marks

Attendance (Theory and practical's): 05 marks

Oral Examination:

Oral exam will be based on the entire syllabus.

CLASS: TE (Mechatronics)	Subject Code: MTC601		Semester:-VI
SUBJECT: **CNC Technology**			Credit-4
Periods per week: 1Period of 60 min.	Lecture	4	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory Examination	3	80
	Internal Assessment		20
	TOTAL		**100**

Pre-requisite:

1. MTC402 Kinematics of Machinery
2. MTC502 Machine Design
3. MTC504 Control Systems
4. MTC503 Sensors and Actuators

Objectives:

1. To understand the importance of NC and CNC technology in manufacturing industry.
2. To understand the application of CAD/CAM systems in generating Part Programmes, in particular for complex models.
3. To understand and apply the use of various transducers, encoders and feedback devices.
4. Identify and select proper NC tooling's.

Outcomes: Learner will be able to…

1. Understand the principles of Numerical Control (NC) technology and describe the range of machine tools to which it is applied.
2. Outline the various routs for part programming in NC and CNC.
3. Explain the application of CNC for Machining & Turning Centers.

Module No.	Details	Hrs
1	**Numerical Control of Machines** 1 Introduction-NC Machine, CNC Machines, DNC, Advantages and Disadvantages of CNC Machines, Applications of CNC 2 Components of Numerical Control System-Basic Components, Programme of Instructions 3 Classification of Numerical Control Machines 4 Engineering Analysis of NC Positioning Systems	06
2	**CNC Control System** CNC motion controller, Linear, circular, parabolic, cubic, helical interpolator, Positioning and contouring control loops, MCU **Output Transducers** Introduction, positional transducers, optical gratings, encoders, Inductosyns, Magnescales.	07
3	**Tooling for CNC machines** Introduction, Cutting tools materials, types of cutting tools, tool selection, ISO specifications, clamping systems in tool holders. Latest CNC tool materials and manufacturing, Tool probing and presetting, Automatic Pallet Changer (APC) and Automatic Turret Changer (ATC), Study of various probes and special tools.	08

4	**4.1 Manual Part Programming** – NC Words, Writing Part Programme for lathe Machine and Milling Machine **4.2 Part Programming using Subroutines, Do Loops and Canned Cycle** – Introduction, Subroutines, Do Loops, Canned Cycles for Lathe Machine and Milling Machine. Introduction to Parametric Programming	12
5	**Computer-aided Part Programming** – Introduction, Computer-aided Part Programming Languages, APT, MACROS, Milling Machine Programs	10
6	Adaptive control – ACO and ACC systems, Maintenance of CNC Machines, Economics of manufacturing using CNC machines, CNC Machine and Automation	09

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 examinations:

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.

References:

1. G. E. Thyer "Computer Numerical Control of Machine Tools", Industrial Press Inc., New York
2. Steve Krar, Arthur Gill, "CNC Technology and Programming",MC Graw Hill
3. Kundra, Rao and Tewari, "Numerical Control and Computer Aided Manufacturing" Tata McGraw-Hill, New Delhi.
4. Mikell P. Groover, "Automation Production Systems, and CIM, Pearson Education
5. Tilak Raj, "CNC Technology and Programming",Dhanpat Rai Publication.
6. Pabla, B.S. &Adithan, M. "CNC Machines", New Age Publishers, New Delhi
7. Ploywka, John & Gabrel, Stanley, "Programming of Computer Numerically Controlled Machines" Industrial Press Inc., New York.
8. Rapello. Ralph. "Essentials of Numerical Control", Prentice Hall
9. Pollack. Herman, W & Robinson., T. "Computer Numerical Control", Prentice Hall
10. Seams, Warren, "Computer Numerical Control: Concepts & Programming", Delmar Publisher Inc. New York

CLASS: TE (Mechatronics)	Subject Code: MTC602		Semester:-VI
SUBJECT: **Metrology and Quality Engineering**			Credit-4
Periods per week: 1Period of 60 min.	Lecture	4	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory Examination	3	80
	Internal Assessment		20
	TOTAL		**100**

Pre-requisite:

1. MTC501 Manufacturing Processes

Objectives:

1. To study the fundamentals of modem quality concepts and statistical techniques.
2. To study fundamentals of inspection methods and systems.
3. To acquaint with operation of precision measurement tools and equipment's.

Outcomes: Learner will be able to…

1. Apply inspection gauge and checking systems.
2. Demonstrate the understanding of purpose of critical dimensions in manufacturing.
3. Analyze simple parts for dimensional accuracy and functionality.

Module	Details	Hrs.
01	1.1 Introduction to Metrology, Fundamental principles and definitions, measurement standards / primary and tertiary standards, distinction between precision and accuracy. 1.2 Limits, fits and tolerances, Tolerance grades, Types of fits, IS919, GO and NO GO gauges- Taylor's principle, design of GO and NO GO gauges, filler gauges, plug gauges and snap gauges.	**08**
02	2.1 Comparators: Constructional features and operation of mechanical, optical, electrical/electronics and pneumatic comparators, advantages, limitations and field of applications. 2.2 Principles of interference, concept of flatness, flatness testing, optical flats, optical interferometer and laser interferometer. 2.3 Surface texture measurement: importance of surface conditions, roughness and waviness, surface roughness standards specifying surface roughness parameters- Ra, Ry, Rz, RMS value etc., surface roughness measuring instruments – Tomlinson and Taylor Hobson versions, surface roughness symbols.	**10**
03	3.1 Screw Thread measurement: Two wire and three wire methods, floating carriage micrometer. 3.2 Gear measurement: Gear tooth comparator, Master gears, measurement using rollers and Parkinson's Tester. 3.3 Special measuring Equipments: Principles of measurement using Tool Maker's microscope, profile projector & 3D coordinate measuring machine.	**10**
04	**Quality Control** Introduction, definition and concept of quality & quality control, set up policy and objectives of quality control, quality of design and quality of conformance, compromise between quality & cost, quality cost and planning for quality.	**08**

05	**SQC and SQC tools** Importance statistical methods in QC, measurement of statistical control variables and attributes, pie charts, bar charts/ histograms, scatter diagrams, pareto chart, GANT charts, control charts, X chart, X bar charts, R charts, P charts, np charts their preparation, analysis and applications. Elementary treatment on modern SQC tools.	**10**
06	**Sampling Techniques** Sampling inspection and basic concepts, OC curves, consumer & producer risk, single & double sampling plans and use of sampling tables.	**6**

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.

References:

1. *Practical Engineering Metrology*, K.W.B.Sharp, Pitman Publication
2. *Engineering Metrology*, K.J.Hume, Kalyani publication
3. *Engineering. Metrology*, I.C. GUPTA, DhanpatRai Publications.
4. *Statistical quality control*, A.L. Grant, McGraw Hill International, New York.
5. *Engineering. Metrology,* R.K.Jain, Khanna Publisher.
6. *Metrology*,Taher.
7. *Statistical Quality control*, R.C. Gupta
8. *I.S. 919/1963.*
9. *I.S. 2709/1964.*
10. *Engineering. Metrology,* Hume K.G., M C Donald, Technical &Scientific ,London.
11. *Quality Control and Industrial Statistics*, – Duncon A.J., D.B. Taraporevela& Co. Bombay.
12. *Statistical quality Control*, Mahajan M., DhanpatRai& Sons, Delhi.
13. *Engineering Metrlogy*-2nd Ed.,P. Narayana, Scitech Publication.
14. *Metal working & Metrology*, P. Narayana et.al ,Scitech Publication.
15. *Quality control* 7 ed.,D.H. Besterfield Pearson education.
16. *Juran's Quality Control Handbook.*

CLASS: TE (Mechatronics)	Subject Code: MTC603		Semester:-VI
SUBJECT: **Dynamics of Machinery**			Credit-4
Periods per week: 1Period of 60 min.	Lecture	4	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory Examination	3	80
	Internal Assessment		20
	TOTAL		**100**

Pre-requisite:

1. MTC402 Kinematics of Machinery
2. MTC502 Machine Design

Objectives:

1. To acquaint with working principles and applications of governors and gyroscope
2. To understand basic principles of vibrations.
3. To study the vibration control and measurement techniques.
4. To study balancing of mechanical systems

Outcomes: Learner will be able to…

1. Demonstrate working mechanism of different governors and analyze gyroscopic effects.
2. Develop mathematical model to represent dynamic system, estimate natural frequency
3. Able to identify vibration control technique and know the working principles of vibration measurement instruments.
4. Remove unbalance in various mechanical systems.

Modules	Details	Hrs
1	**Controlling Mechanisms – Governors:** 3.1. Governors: Types, centrifugal governors, inertia governors, 3.2. Force analysis of gravity loaded governors - Watt, Proell, Performance characteristics of governors - stability, sensibility, isochronisms, Hunting, governor effort and governor power, coefficient of insensitiveness.	06
2	**Controlling Mechanisms – Gyroscope:** Gyroscope: Introduction - Gyroscopic couple and its effect on spinning bodies, Gyroscopic effect on naval ships during steering, pitching and rolling, Ship stabilization with gyroscopic effect. Effect of gyroscopic and centrifugal couples, maximum permissible speeds on curve paths, Gyroscopic effect due to lateral misalignment of rigid disc mounted on shaft.	06
3	**Basic Concepts of Vibration** Vibration and oscillation, causes and effects of vibrations, Vibration parameters – spring, mass, damper, Damper models, Motion – periodic, non periodic, harmonic, non- harmonic, Degree of freedom, static equilibrium position, Vibration classification, Steps involved in vibration analysis. **Modeling of Single Degree of Freedom Dynamic System** Longitudinal, gransverse, torsional vibration system, Methods for formulation of differential equations by Newton, Energy, Lagrangian and Rayleigh's Method.	10
4	**Free Un-damped and damped Single Degree of Freedom Vibration System** Free vibration of undamped translation and torsional systems. Free vibration of viscous damped system – under damped, critically damped, over damped; Logarithmic decrement; Coulomb's damping;	10

	Combined viscous and coulomb's damping. **Forced Single Degree of Freedom Vibratory System** Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation (excluding elastic damper).	
5	**Vibration Measurement and Control:** **Vibration Control:** Force Transmissibility, Motion Transmissibility. Vibration isolation with rigid, flexible, and partially flexible foundation, shock isolation, Typical isolators and Mounts. Undamped dynamic vibration absorber, Damped dynamic vibration absorber, active vibration control. **Vibration Measurement :** **Vibration pickups:** Principle of seismic instruments, vibrometer, accelerometer, phase distortion, filters. Sensor characteristics, transducer response to transient inputs, accelerometer cross-axis sensitivity, calibration, environmental factors, Basic processes and operating principle of a digital frequency analyser.	10
6	**Introduction to Conditioning Monitoring and Fault Diagnosis:** Vibration severity criteria, Machine maintenance techniques, machine conditioning monitoring techniques, vibration monitoring techniques, instrumentation systems, choice of monitoring parameter. **Balancing:** Static and dynamic balancing of rotating masses, balancing of single and multi-cylinder engines, balancing of linkages, balancing machines, balancing of discs and rotors.	10

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 examinations:

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.

References:

1. Theory of Machines - Thomas Bevan - C. B. S. Publishers
2. Theory of Machines - S. S. Ratan - Tata McGraw Hill
3. Theory of Machines - P. L. Ballaney, Khanna Publishers, Delhi
4. Dynamics of Machines – Norton, McGraw Hill Publication
5. Theory of Mechanisms and Machines - A. Ghosh and A. Malik - Affiliated East – West Press Pvt. Ltd., New Delhi
6. Theory of Machines - W. G. Green – Bluckie & Sons Ltd.
7. Mechanics & Dynamics of Machinery - J. Srinivas, Scitech
8. Kinematics, Dynamics and Design of Machinery, 2nd ed., Kenneth Waldron, Gary Kinzel, Wiley India Edition.
9. Mechanical Vibrations by S. S. Rao
10. Vibration Testing; Theory and Practice, 2nd Edition, Kenneth G. McConnell, Paulo S. Varoto.

CLASS: TE (Mechatronics)	Subject Code: MTC604		Semester:-VI
SUBJECT: **Power Electronics and Drives**			Credit-4
Periods per week: 1Period of 60 min.	Lecture	4	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory Examination	3	80
	Internal Assessment		20
	TOTAL		**100**

Pre-requisite:

1. EXC305: Applied Electrical and Electronics Engineering

Objectives:

1. To teach power semiconductor switches and power converters.
2. To teach different controlling methods for industrial drives.

Outcomes: Learner will be able to...

1. Discuss tradeoffs involved in power semiconductor switches
2. Analyze different types of power converters.
3. Analyze issues involved in controlling of AC and DC drives.
4. Realize drive considerations for different industrial applications.

Module	Topics	Hrs
1. 0	**Power Semiconductor Switches** 1.1 SCR: Principle of operation, static and dynamic characteristics, gate characteristics, turn-on and turn-off methods, protection. 1.2 Principle of operation and characteristics of: TRIAC, power BJT, power MOSFET, IGBT.	10
2.0	**AC-DC Converters** 2.1 **Phase Controlled Converters :** Working and waveforms of : Single phase semi, full converters with R, R-L load. 2.2 **Switched-mode rectifiers**: Principle of operation.	08
3.0	3.1 **DC-DC converters:** Basic principle of step up and step down choppers. Buck, Boost, Buck-Boost, Cuk regulators. 3.2 **Inverters (DC-AC):** Single phase half / full bridge voltage source inverters with R load, Voltage control of single phase inverters using PWM techniques.	08
4.0	**AC-AC Converters** 4.1 **AC voltage Controllers:** Single phase AC voltage controller – on – off control and phase control. **4.2 Cycloconverters:** principle of operation of single phase step-up and step-down cycloconverters.	06
5.0	**DC Drives** 5.1 **DC Drive Operation:** Introduction to Four quadrant operation – Motoring, Plugging, Dynamic and Regenerative Braking. 5.2**Control of DC Drive by phase controlled converter:** Speed control of DC drives, Single phase, semi/ full converter drive for separately excited dc motor. 5.3 **Control of DC Drive by Chopper regulators:** Single quadrant, Two – quadrant and four quadrant chopper fed dc separately excited motors, Continuous current operation, Output voltage and current wave forms, Speed torque expressions, speed torque characteristics.	10

6.0	**AC Drives** Induction Motor Characteristics, Current Source Inverter fed Induction motor drive, Speed control methods: Stator voltage, Variable frequency, Rotor resistance, V/F control, PWM Control, Closed-loop control.	10
Total		52

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 examinations:

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.

References:

1. Reshid, M.H., "Power Electronics – Circuits Devices and Application" Prentice Hall International, New Delhi.
2. J Mohan Undeland and Robbins, "Power Electronics", John Wilry and Sons, New York.
3. P. C. Sen, "Power Electronics", Tata McGraw-Hill, New Delhi.
4. Singh, M.D., Khanchandani, K.B., "Power Electronics", Tata McGraw-Hill Education Pvt. Ltd, New Delhi.
5. S. K. Mandal, "Power Electronics", McGraw-Hill Education (I) Pvt. Ltd, New Delhi.
6. Vedam Subramanyam, "Thyristor Control of Electric drives", Tata McGraw Hill Publilcations
7. P.S. Bimbhra, Power Electronics, Khanna Publications.
8. Vedam Subramanyam, "Electric Drives: Concepts & Applications", 2nd edition, Tata McGraw Hill Education, New Delhi.

CLASS: TE (Mechatronics)	Subject Code: MTC605		Semester:-VI
SUBJECT: **Instrumentation and Control**			Credit-4
Periods per week: 1Period of 60 min.	Lecture	4	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory Examination	3	80
	Internal Assessment		20
	TOTAL		**100**

Pre-requisite:

1. MTC504 Control Systems
2. MTC503 Sensors and Actuators

Objectives:

1. To teach fundamental Process controller and its design
2. To educate students the criteria for selection of suitable transmitters (Sensor/Actuators)
3. To help students in enhancing their knowledge about different controllers

Outcomes: Learner will be able to...

1. Select proper transmitter for different parameters
2. Use suitable actuators for different situations
3. Design controller for different processes and applications
4. Write the ladder diagram programs for in industrial application.

Module	Topics	Hrs.
1. 0	**Fundamentals of process and control** 1.1 Elements of process control loop, Concept of Process variables, set point, controlled variable, manipulated variable, load variable. Representation of Process loop components using standard symbols (basics with reference to control loop), and Examples of process loops like temperature, flow, level, pressure etc. Current to pneumatic converter & Pressure to Current converter. 1.2 Process Characteristics: Process load, Process lag, Self Regulation, Distance/velocity lag (dead time), Capacity. Control System Parameters Error, Variable Range, Control Lag, Cycling, Direct/Reverse Action.	08
2.0	**Transmitters:** 2.1 Need of transmitter (concept of field area & control room area), Need for standardization of signals, Current, voltage, and pneumatic signal standards, Concept of live & dead zero 2.2 Types of transmitters: Two and four wire transmitters, Electronic and Pneumatic transmitters Electronic Differential Pressure Transmitter	08
3.0	**Actuators** 3.1 **Control valve :**Necessity, comparison with other final control elements, Control valve Characteristics (Inherent & Installed) Control valve terminology: Range ability, Turndown, valve capacity, viscosity index, AO, AC (Fail Safe Action) etc. Classification of control valve based on: valve body. Construction, type of actuation, application etc. Construction, Advantages, Disadvantages & applications of Globe: Single, double, 3way, angle, Gate, Needle, Diaphragm, Rotary valves, Ball, Butterfly. 3.2 **Types of actuators:** Construction, Advantages, Disadvantages & applications: Spring Diaphragm & Smart actuators. Control valve accessories: Positioners:	10

	Applications/Need, Types, Effect on performance of Control valves. Volume boosters, Pressure boosters, Reversing relay, Solenoid valves, Air lock, Position indicating switches, Electro pneumatic converter, Hand wheel, Motors.	
4.0	**Controller** 4.1 **Discontinuous:** ON/OFF, Multi-position Control, Floating Control. 4.2 **Continuous:** Proportional (offset), Integral (Reset windup), Derivative, Proportional- Integral, Proportional- Derivative, Proportional- Integral-derivative, Anti-reset windup, Rate before Reset, Concept of Bump less transfers in PID controller, Effect of process characteristics on PID combination, Selection & application of controller actions.	08
5.0	**Tuning of controller:** 5.1 **Different Criteria**: Quarter Amplitude Decay Ratio, Loop disturbance, Optimum Control, Measure of Quality, Stability Criteria Tuning Methods: Process Reaction Curve (open loop), Ziegler Nichols (closed loop),& Frequency Response Method. 5.2 **Digital PID controllers :** : Velocity & Position algorithm, Block Schematic, Faceplate of Digital controller, Direct Digital Control. Continuous versus Discrete Process Control, Relay based ladder diagram using standard symbols, Limitations of relay based system.	08
6.0	**Programmable Logic Controller (PLC)** 6.1 Architecture of PLC, Types of Input & Output modules (AI, DI, DO, AO), Wiring diagram, 6.2 PLC Basic instructions, Timers & Counters, PLC ladder diagram, PLC programming for process applications, 6.3 Interfacing pneumatic & Hydraulic systems to PLC, Fixed & Modular PLC (Rack, slot, grouping), PLC specifications, PLC manufacturers,	10
		52

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 examinations:

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.

References:

1. Process control and Instrument technology, C.D.Johnson, TMH
2. Instrumentation for Process measurement and control , N.A. Anderson, CRC Press
3. Introduction to Programmable Logic Controller, Gary Dunning, DELMAR Cengage Learning.
4. Programmable Logic Controller, Webb, PHI Reference Books
5. Tuning of Industrial control systems, ISA
6. Control valve Handbook, ISA
7. Process Instruments and Controls Handbook, Douglas M. Considine, McGraw-Hill.
8. Process Control, Instrument Engineering Hand book, B.G. Liptak, Butterworth-Heinemann Ltd
9. Programmable Logic Controller, NIIT
10. Fundamentals of Process Control Theory, Paul Murrill, ISA
11. Lessons in Industrial Instrumentation, By Tony R. Kuphaldt, Version 0.4 – Released Jan 11, 2009.

CLASS: TE (Mechatronics)	Subject Code: MTC606	Semester:-VI
SUBJECT: **APPLIED HYDRAULICS AND PNEUMATICS**		Credit-4

Periods per week: 1Period of 60 min.	Lecture	4	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory Examination	3	80
	Internal Assessment		20
	TOTAL		**100**

Pre-requisite:

1. MTC503 Sensors and Actuators

Objectives:

1. To study fundamentals of fluid power system.
2. To study pneumatics & hydraulic system and its components.
3. To study PLC system and its applications.

Outcomes: Learner will be able to...

1. Design the pneumatic and electro-pneumatic system.
2. Design hydraulic and electro-hydraulic system.
3. Design PLC for various applications.

Module	Detailed Contents	Hours
1	**Fluid Power Systems and Fundamentals** Introduction to fluid power, Advantages of fluid power, Application of fluid power system. Types of fluid power systems, Properties of hydraulic fluids, General types of fluids, Fluid power symbols. Basics of Hydraulics, Applications of Pascals Law, Laminar and Turbulent flow, Reynold's number, Darcy's equation, Losses in pipe, valves and fittings.	06
2	**Hydraulic System & Components** Sources of Hydraulic Power: Pumping theory, Pump classification – Gear pump, Vane Pump, piston pump, construction and working of pumps, pump performance, Variable displacement pumps. Fluid Power Actuators: Linear hydraulic actuators, Types of hydraulic cylinders – Single acting, Double acting, Cushioning mechanism, Construction of double acting cylinder.	08
3	**Design of Hydraulic Circuits** Construction of Control Components : Directional control valves, Shuttle valve, check valve, pressure control valve, pressure reducing valve, counter balance valve, unloading valves, sequence valve, Flow control valve – Fixed and adjustable, Accumulators and Intensifiers: Types of accumulators – Accumulators circuits, intensifier – Applications of Intensifier – Intensifier circuit, regenerative circuit, Meter in and meter out circuit, sequence circuit.	10
4	**Pneumatic Systems and Components** Pneumatic Components: Properties of air, Compressors, Filter, Regulator, Lubricator Unit, classification of pneumatic actuators, Air control valves, Quick exhaust valves, directional control valves, non-return valves, logic valves, time delay valves, pressure sequence valve,	08
5	**Design of Pneumatic Circuits** Pneumatic logic circuits for various applications. Displacement step diagram, Speed control circuits, hydro-pneumatic circuit, sequential circuit design for various applications using cascade and shift register method.	10

6	**Development of circuits for industrial automation** Electro-pneumatic systems, electrical control solenoid valves, Relays, Dominant OFF and Dominant ON circuit, Electro-hydraulic system, hydro-pneumatic system, Programmable Logic Controller (PLC) in automation: Basic structure, I/O processing. Ladder logic diagram, PLC for industrial process control, Selection of PLC.	10

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 examinations:

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.

References:

1. A text book on Fluid mechanics and Hydraulic machines: Sukumar Pati, 2012 Tata McGraw Hill.
2. Fluid Power with Applications by Anthony Esposito - Pearson Education 2000.
3. Power Hydraulics by Michael J, Prinches and Ashby J. G, - Prentice Hall, 1989
4. Industrial Hydraulics: Pippenger
5. Vickers Manual on Hydraulics
6. Fluid Mechanics and Fluid Power Engineering by Dr.D S Kumar , Kataria Publishers 2014
7. Fluid Mechanics and Hydraulic machines by Modi & Seth, Standard Publishers Distributors
8. Pneumatic Controls by Joji P, Wiley India Pvt.Ltd
9. Pneumatic Circuits and Low Cos by Fawcett J.R.
10. Fundamentals of pneumatics: Festo series
11. Fundamentals of hydraulics: Festo series
12. Mechatronics, A. Smaili, F. Mrad, *OXFORD Higher Education.*
13. Mechatronics by K P Ramachandran, G K Vijayaraghavan, M S Balasundaram, Wiley India Pvt.Ltd.

CLASS: TE (Mechatronics)	Subject Code: MTL607	Semester:-VI
SUBJECT: **CNC Technology Laboratory**		Credit: 1
Practical to be conducted for batch of students	Practical	Slot of 02 hours per week

Pre-requisite:

1. MTC501 Manufacturing Processes
2. MTC503 Sensors and Actuators

Objective:

1. To give a job oriented training on the CNC Lathe and CNC Milling Machine.
2. To study programming and machining on CNC Lathe and CNC Milling.
3. To study select/apply/implement tooling, machine setting, work holding techniques etc. along with basic maintenance

Outcomes: Learner will be able to ...

1. Illustrate the importance of NC and CNC technology in manufacturing industry.
2. Generate Part Programming with application of CAD/CAM systems in particular for complex models.
3. Identify and select proper NC toolings.

Modules.	Details	Hrs
1	Study and operation of CNC Lathe	01
2	Study and operation of CNC Milling Center	01
3	Manufacturing Simulation using Software like Master CAM	02
4	Part programming and operation of CNC Lathe for facing, turning and threading operations	05
5	Part programming and operation of CNC Milling Center	05

Term work:

Distribution of marks for Term work shall be as follows:

Laboratory work (experiments): 20 marks

Attendance (Practicals) : 05 marks

Practical and Oral Examination:

Practical examination of 3 hours duration based on part programming and operation on any one of the CNC centre.

Marks distribution: 25 Marks = Practical examination (20 Marks) + Oral examination (05 Marks).

Practical and Oral examination is to be conducted by pair of internal and external examiners

References:

1. Pabla, B.S. &Adithan, M. “CNC Machines”, New Age Publishers, New Delhi
2. Ploywka, John &Gabrel, Stanley, “Programming of Computer Numerically Controlled Machines” Industrial Press Inc., New York.
3. Rapello. Ralph. “Essentials of Numerical Control”, Prentice Hall
4. Pollack. Herman, W & Robinson., T. “Computer Numerical Control”, Prentice Hall
5. Seams, Warren, “Computer Numerical Control: Concepts & Programming”, Delmar Publisher Inc. New York.
6. Kundra, Rao and Tewari, “Numerical Control and Computer Aided Manufacturing” Tata McGraw-Hill, New Delhi.

CLASS: TE (Mechatronics)	Subject Code: MTL608	Semester:-VI
SUBJECT: **Metrology and Quality Engineering Laboratory**		Credit: 1
Practical to be conducted for batch of students	Practical	Slot of 02 hours per week

Pre-requisite:

1. MTC501 Manufacturing Processes

Objectives:

1. To study the fundamentals of modem quality concepts and statistical techniques.
2. To study fundamentals of inspection methods and systems.
3. To acquaint with operation of precision measurement tools and equipment's.

Outcomes: Learner will be able to…

1. Apply inspection gauge and checking systems.
2. Demonstrate the understanding of purpose of critical dimensions in manufacturing.
3. Analyse simple parts for dimensional accuracy and functionality.

List of Experiments:

1. Use of comparators.
2. Thread measurement.
3. Gear measurement.
4. Use of Profile projectors.
5. Use of linear and angular measuring instruments.
6. Measurement of surface roughness.
7. Measurement of flatness.

Term Work:

Term work shall consist of 7 experiments from the list and presented with inferences and one assignment on each module

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

1. Laboratory work (Experiments) **:** **10 marks**
2. Assignments : **10 marks**
3. Attendance (Practicals)**:** **05 marks**

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

CLASS: TE (Mechatronics)	Subject Code: MTL609	Semester:-VI
SUBJECT: **Instrumentation and Control Laboratory**		Credit: 1
Practical to be conducted for batch of students	Practical	Slot of 02 hours per week

Pre-requisite:

1. MTC504 Control Systems
2. MTC503 Sensors and Actuators

Objectives:

1. To study the basic of instrumentation
2. To study control startaegies

Outcomes: Learner will be able to...

1. Demonstrate basic integrated circuits
2. Use PID controller
3. Implement PLC programming for process
4. Develop automation circuits for industrial applications

List of Practical's:

1) Demonstration of I(Current)/P(Pressure) and P(Pressure)/I(Pressure) converter using integrated Circuits
2) P, PI, PD and PID Controller its performance and tuning
3) PLC programming(Ladder diagram, Instruction list and Functional Block Diagram)
4) Electro-pneumatic controller (Counters, switches and Cylinders)
5) Electro- hydraulic controller
6) Simulation case studies based on the syllabus

Term Work:

Term work shall consist of 6 experiments from the list and presented with inferences and one assignment on each module.

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

1. Laboratory work (Experiments) **:** **10 marks**
2. Assignments (Practicals): **10 marks**
3. Attendance **05 marks**

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Practical and Oral Examination:

Practical examination of 2 hours duration based on experiments mentioned in the list.

Marks distribution: 25 Marks = Practical examination (15 Marks) + Oral examination (10 Marks).

Practical and Oral examination is to be conducted by pair of internal and external examiners

CLASS: TE (Mechatronics)	Subject Code: MTL610	Semester:-VI
SUBJECT: **APPLIED HYDRAULICS AND PNEUMATICS LABORATORY**		Credit: 1
Practical to be conducted for batch of students	Practical	Slot of 02 hours per week

Pre-requisite:

1. MTC503 Sensors and Actuators

Objectives:

1. To study fundamentals of fluid power system.
2. To study pneumatics & hydraulic system and its components.
3. To study PLC system and its applications.

Outcomes: Learner will be able to...

1. Design the pneumatic and electro-pneumatic system.
2. Design hydraulic and electro-hydraulic system.
3. Demonstrate use of PLC for various industrial applications.

Module	Detailed Contents	Hours
1	Design and implementation of pneumatics and electro-pneumatic circuits using hardware and software	04
2	Design and implementation of hydraulics and electro-hydraulics circuits using hardware and software	04
3	Characteristics of reciprocating pumps, gear pump etc.	02
4	Case studies on PLC for industrial automation	04

(Usage of simulation software, fluidsim, Automation studio etc shall be encouraged to design and simulate experiments based on hydraulics, pneumatics, electro pneumatics, electro hydraulics and PLC).

Term Work:

Term work shall consist of performance of above mentioned experiments from the list and 2 numerical / case studies on each Module.

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

- Laboratory work (Experiments) : 10 marks
- Assignments / Case studies : 10 marks
- Attendance : 05 marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Practical and Oral examination:

Practical and Oral (based on term work) examination is to be conducted by pair of internal and external examiners. Practical examination of 2 hours duration based on performance based experiments mentioned from the list of experiments.

Marks distribution: 25 Marks = Practical examination (15 Marks) + Oral examination (10 Marks).