

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

S. E. Mechatronics - (Semester III)

Subject Code	Subject Name	Teaching Scheme (Contact Hours)		Credits Assigned					
		Theory	Pract.	Theory	Pract.	Total			
MTC301	Applied Mathematics III [§]	4	--	4	--	4			
MTC302	Thermodynamics and Heat Transfer	4	--	4	--	4			
MTC303	Engineering Materials and Metallurgy	4	--	4	--	4			
MTC304	Digital Electronics	4	--	4	--	4			
MTC305	Applied Electrical and Electronics Engineering	4	--	4	--	4			
MTL306	Computer Aided Machine Drawing Laboratory [§]	--	2*+4	--	3	3			
MTL307	Object Oriented Programming Laboratory	--	2*+2	--	2	2			
MTL308	Applied Electronics Laboratory-I	--	2	--	1	1			
MTL309	Engineering Materials and Metallurgy Laboratory	--	2	--	1	1			
Total		20	14	20	7	27			
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.					
MTC301	Applied Mathematics III [§]	20	20	20	80	03	--	--	100
MTC302	Thermodynamics and Heat Transfer	20	20	20	80	03	--	--	100
MTC303	Engineering Materials and Metallurgy	20	20	20	80	03	--	--	100
MTC304	Digital Electronics	20	20	20	80	03	--	--	100
MTC305	Applied Electrical and Electronics Engineering	20	20	20	80	03	--	--	100
MTL306	Computer Aided Machine Drawing Laboratory [§]	--	--	--	--	--	50	50	100
MTL307	Object Oriented Programming Methodology Laboratory	--	--	--	--	--	50	50	100
MTL308	Applied Electronics Laboratory-I	--	--	--	--	--	25	25	50
MTL309	Engineering Materials and Metallurgy Laboratory	--	--	--	--	--	25	--	25
Total		--	--	100	400	--	150	125	775

* Theory for entire class to be conducted, [§]Course common with Mechanical Engineering

S. E. Mechatronics -(Semester IV)

Subject Code	Subject Name	Teaching Scheme (Contact Hours)		Credits Assigned					
		Theory	Pract.	Theory	Pract.	Total			
MTC401	Applied Mathematics IV [§]	4	--	4	--	4			
MTC402	Kinematics of Machinery	4	--	4	--	4			
MTC403	Fluid Mechanics and Machinery	4	--	4	--	4			
MTC404	Strength of Materials	4	--	4	--	4			
MTC405	Application of Integrated Circuits	4	--	4	--	4			
MTC406	Signals and Systems	4	--	4	--	4			
MTL407	Applied Electronics Laboratory-II	--	2	--	1	1			
MTL408	Electrical and Electronics Workshop	--	2	--	1	1			
MTL409	Strength of Materials Laboratory	--	2	--	1	1			
Total		24	6	24	3	27			
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.					
MTC401	Applied Mathematics IV [§]	20	20	20	80	03	--	--	100
MTC402	Kinematics of Machinery	20	20	20	80	03	--	--	100
MTC403	Fluid Mechanics and Machinery	20	20	20	80	03	--	--	100
MTC404	Strength of Materials	20	20	20	80	03	--	--	100
MTC405	Application of Integrated Circuits	20	20	20	80	03	--	--	100
MTC406	Signals and Systems	20	20	20	80	03	--	--	100
MTL407	Applied Electronics Laboratory-II	--	--	--	--	--	25	25	50
MTL408	Electrical and Electronics Workshop	--	--	--	--	--	50	25	75
MTL409	Strength of Materials Laboratory	--	--	--	--	--	25	25	50
Total		--	--	120	480	--	100	75	775

§Course common with Mechanical Engineering

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					End Sem. Exam.	Exam. Duration (in Hrs)	Term Work	Pract. /oral	Total
		Internal Assessment			Avg.						
		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		

Program Structure for B E Mechatronics Engineering

B. E. Mechatronics-(Semester VII)

Subject Code	Subject Name	Teaching Scheme (Contact Hours)		Credits Assigned										
		Theory	Pract.	Theory	Pract.	Total								
MTC701	CAD/CAM/CAE [§]	4	--	4	--	4								
MTC702	Manufacturing Planning and Control	4	--	4	--	4								
MTC703	Communication Systems	4	--	4	--	4								
MTC704	Automotive Electronics	4	--	4	--	4								
MTE705X	Elective- I	4	--	4	--	4								
MTL706	CAD/CAM/CAE Laboratory	--	2	--	1	1								
MTL707	Communication Systems Laboratory	--	2	--	1	1								
MTEL705X	Elective- I Laboratory	--	2	--	1	1								
MTP706	Project- I	--	4 [#]	--	3	3								
Total		20	10	20	6	26								
Subject Code	Subject Name	Examination Scheme												
		Theory					End Sem. Exam.	Exam. Duration (in Hrs)	Term Work	Pract. /oral	Total			
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)						Term Work	Pract. /oral	Total
		Test1	Test 2	Avg.										
MTC701	CAD/CAM/CAE [§]	20	20	20	80	03	--	--	100					
MTC702	Manufacturing Planning and Control	20	20	20	80	03	--	--	100					
MTC703	Communication Systems	20	20	20	80	03	--	--	100					
MTC704	Automotive Electronics	20	20	20	80	03	--	--	100					
MTE705X	Elective- I	20	20	20	80	03	--	--	100					
MTL706	CAD/CAM/CAE Laboratory	--	--	--	--	--	25	25	50					
MTL707	Communication Systems Laboratory	--	--	--	--	--	25	25	50					
MTEL705X	Elective- I Laboratory	--	--	--	--	--	25	25	50					
MTP706	Project- I	--	--	--	--	--	50	--	50					
Total		--	--	100	400	--	125	75	700					

[§]Course common with Mechanical Engineering

B. E. Mechatronics-(Semester VIII)

Subject Code	Subject Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
MTC801	Design of Mechatronic Systems	4	--	4	--	4
MTC802	Engineering Management and Economics	4	--	4	--	4
MTC803	Modeling and Simulation	4	--	4	--	4
MTE804X	Elective- II	4	--	4	--	4
MTL805	Simulation Laboratory	--	2	--	1	1
MTL806	Mechatronics Laboratory	--	2	--	1	1
MTP807	Project- II	--	12 [#]	--	6	6
Total		16	16	16	8	24

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.					
MTC801	Design of Mechatronic Systems	20	20	20	80	03	--	--	100
MTC802	Engineering Management and Economics	20	20	20	80	03	--	--	100
MTC803	Modeling and Simulation	20	20	20	80	03	--	--	100
MTE804X	Elective- II	20	20	20	80	03	--	--	100
MTL805	Simulation Laboratory	--	--	--	--	--	50	25	75
MTL806	Mechatronics Laboratory	--	--	--	--	--	50	25	75
MTP807	Project- II	--	--	--	--	--	50	100	150
Total		--	--	80	320	--	150	150	700

indicates work load of Learner (Not faculty) in VII and VIII semester for Project

Student group size and load of faculty per week for Project I and II shall be as follows:

Project Groups: Students can form groups with minimum 2 (Two) and not more than 4 (Four)

Faculty Load : In semester VII 1/2 hour per week per project group

In semester VIII 1 hour per week per project group

Each faculty is permitted to take (guide) maximum 4 (Four) project groups.

Course codes	Elective I	Course codes	Elective II
MTE7051	Digital Signal Processing	MTE8041	Medical Mechatronics
MTE7052	Neural Network and Fuzzy Logic	MTE8042	Robotics and Machine Vision
MTE7053	Micro-Electro Mechanical Systems	MTE8043	Microfabrication Processes
MTE7054	Optimization	MTE8044	Machine Interface Design
MTE7055	Finite Element Analysis	MTE8045	Product Design and Development

CLASS: SE (Mechatronics)		Subject Code: MTC301		Semester:-III	
SUBJECT: Applied Mathematics III				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. FEC101 Applied Mathematics I
2. FEC201 Applied Mathematics II

Objectives:

1. To provide sound foundation in the mathematical fundamentals necessary to formulate, solve and analyze engineering problems.
2. To study the basic principles of Laplace Transform, Fourier series, Complex Variables.

Outcomes: Learner will be able to

1. Demonstrate the ability of using Laplace Transform and Fourier series in solving the Ordinary Differential and Partial Differential Equations.
2. Identify the analytic function, harmonic function, orthogonal trajectories and to apply bilinear transformations and conformal mappings.
3. Identify the applicability of theorems and evaluate the contour integrals.

Module	Details	Hrs
1	<p>Laplace Transform</p> <p>1.1 Function of bounded variation, Laplace Transform of standard functions such as $1, t^n, e^{at}, \sin at, \cos at, \sinh at, \cosh at$</p> <p>1.2 Linearity property of Laplace Transform, First Shifting property, Second Shifting property, Change of Scale property of L.T. (without proof)</p> $L\{t^n f(t)\}, L\left\{\frac{f(t)}{t}\right\}, L\left\{\int_0^t f(u)du\right\}, L\left\{\frac{d^n f(t)}{dt^n}\right\}$ <p>Heaviside Unit step function, Dirac Delta function, Periodic functions and their Laplace Transform.</p>	6
2	<p>Inverse Laplace Transform</p> <p>2.1 Linearity property, use of theorems to find inverse Laplace Transform, Partial fractions method and convolution theorem.</p> <p>2.2 Applications to solve initial and boundary value problems involving ordinary differential equations with one dependent variable.</p>	6
3	<p>Complex variables:</p> <p>3.1 Functions of complex variable, analytic function, necessary and sufficient conditions for $f(z)$ to be analytic (without proof), Cauchy-Riemann equations in polar coordinates.</p> <p>3.2 Milne- Thomson method to determine analytic function $f(z)$ when its real or imaginary or its combination is given. Harmonic function, orthogonal trajectories.</p> <p>3.3 Mapping: Conformal mapping, linear, bilinear mapping, cross ratio, fixed points and standard transformations such as Rotation and magnification, inversion and reflection, translation.</p>	10

4	<p>Complex Integral</p> <p>4.1 Line integral of a function of a complex variable, Cauchy's theorem for analytic function, Cauchy's Goursat theorem (without proof), properties of line integral, Cauchy's integral formula and deductions.</p> <p>4.2 Singularities and poles:</p> <p>4.3 Taylor's and Laurent's series development (without proof)</p> <p>4.4 Residue at isolated singularity and its evaluation.</p> <p>4.5 Residue theorem, application to evaluate real integral of type</p> $\int_0^{2\pi} f(\cos \theta, \sin \theta) d\theta, \text{ and } \int_{-\infty}^{\infty} f(x) dx$	10
5	<p>Fourier Series</p> <p>5.1 Orthogonal and orthonormal functions, Expressions of a function in a series of orthogonal functions. Dirichlet's conditions. Fourier series of periodic function with period 2π & $2l$.</p> <p>5.2 Dirichlet's theorem(only statement), even and odd functions, Half range sine and cosine series, Parsvel's identities (without proof)</p> <p>5.3 Complex form of Fourier series.</p>	10
6	<p>Partial Differential Equations</p> <p>6.1 Numerical Solution of Partial differential equations using Bender-Schmidt Explicit Method, Implicit method(Crank- Nicolson method) Successive over relaxation method.</p> <p>6.2 Partial differential equations governing transverse vibrations of an elastic string its solution using Fourier series.</p> <p>6.3 Heat equation, steady-state configuration for heat flow.</p> <p>6.4 Two and Three dimensional Laplace equations.</p>	10

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) From module 3 then part (b) shall be from any module other than module 3)

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

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.

References:

1. Elements of Applied mathematics, P N & J N Wartikar, Pune VidyarthiGruhaPrakashan
2. Higher Engineering Mathematics, Dr B. S. Grewal, Khanna Publication
3. Advanced Engineering Mathematics, E Kreyszing, Wiley Eastern Limited
4. Integral Transforms and their Engineering Applications, Dr B. B. Singh, Synergy Knowledgeware, Mumbai
5. Complex Variables: Churchill, Mc-Graw Hill
6. Numerical Methods, Kandasamy, S. Chand & CO.

CLASS: SE (Mechatronics)	Subject Code: MTC302	Semester:-III	
SUBJECT: Thermodynamics and Heat Transfer			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. FEC102 Applied Physics-I
2. FEC202 Applied Physics-II

Objectives:

1. Study of basic concepts and laws of thermodynamics.
2. Study of modes of heat transfer and governing laws.
3. Study and analysis of Boilers, turbines and heat exchangers

Outcomes: Learner will be able to...

1. Demonstrate understanding of basic concepts of thermodynamics
2. Analyze basic power cycles.
3. Identify & explain the three modes of heat transfer (conduction, convection and radiation).
4. Develop mathematical model for each mode of heat transfer
5. Demonstrate and explain mechanism of boiling and condensation
6. Design and analyze different heat exchangers

Module	Detailed Contents	Hrs.
01	<p>Introduction and Basic Concepts: Application areas of thermodynamics, Systems and Control volumes, Properties of system, Continuum, State and equilibrium, Processes and cycles, Temperature and Zeroth law of thermodynamics, Heat and thermodynamic concept of work.</p> <p>First Law of Thermodynamics: Statement, Heat and work calculations, Application of first law to non-flow and flow systems, steady flow energy equation as applied to boiler, condenser, nozzle and turbine.</p> <p>Second Law of Thermodynamics: Statements and their equivalence, thermal energy reservoirs, concept of heat engine, refrigerator, heat pump and perpetual motion machines, Carnot cycle and principles.</p> <p>Entropy: Concept of entropy, Temperature- entropy plot, Clausius inequality, Principle of Increase of entropy, entropy balance.</p>	09
02	<p>Boilers Fire tube and Water tube boiler, Low pressure and high pressure boilers, once through boiler, examples, and important features of HP boilers, Mountings and accessories, Layout of a modern HP boiler, Boiler performance, Boiler efficiency. Properties of steam like dryness fraction; enthalpy; internal energy and entropy, Steam table and Mollier Diagram.</p> <p>Steam Turbines Impulse turbines, Reaction turbines, velocity diagram, degree of reaction, compounding of steam turbines, Parson's turbine, condition for maximum efficiency.</p>	09

03	<p>Internal Combustion Engines Air standard cycles, Carnot, Otto, diesel, dual cycles and their comparison, Two stroke and Four stroke engines, CI and SI engines, Environmental and pollution control issues and remedies</p> <p>Gas Turbines Ideal and actual Brayton cycle, open and closed cycle gas turbine, Applications of gas turbine in aviation and power generation,</p>	09
04	<p>Heat Transfer Typical heat transfer situations, Modes of heat transfer</p> <p>Conduction Fourier's law of heat conduction, thermal conductivity, differential equation of heat conduction with heat generation in unsteady state in the Cartesian coordinate system, Steady heat conduction in plane walls, composite walls, Concept of thermal resistance and thermal resistance network, Heat conduction in cylinders and spheres, (Derivation NOT INCLUDED for Cylindrical as well as Spherical coordinate systems), Critical thickness/radius of insulation and its importance.</p> <p>Transient Heat Conduction Lumped system analysis, One dimensional transient problems analytical solutions</p>	09
05	<p>Convection Physical mechanism of convection, Natural and Forced convection, Laminar flow heat transfer in circular pipe, constant heat flux and constant wall temperature, Turbulent flow heat transfer in circular pipes, Pipes of other cross sections, Heat transfer in laminar and turbulent flow over a flat plate, Principles of dimensional analysis and its application in convective heat transfer, Physical significance of various dimensionless numbers useful in natural and forced convection</p> <p>Radiation Basic laws of radiation (Plank's law, Kirchoff's law, Stefan-Boltzman law, Wien's displacement law, Lambert's cosine law), Radiation exchange between black surfaces, Shape factor, Radiation exchange between gray surfaces, Radiation shield and the radiation effect</p>	09
06	<p>Boiling and Condensation Pool boiling, Flow boiling, Film condensation, Drop wise condensation</p> <p>Heat Exchangers Types of heat exchangers, Overall heat transfer coefficient, Analysis of heat exchangers, LMTD method, Effectiveness-NTU method</p>	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. Introduction to Thermodynamics and Heat Transfer, Yunus Cengel, 2nd ed, McGraw-Hill
2. Fundamentals of Thermodynamics, Sonntag, Borgnakke, Van Wylen, Wiley India Pvt. Ltd.
3. Applied Thermodynamics, Onkar Singh, 3rd ed, New Age International
4. Basic Engineering Thermodynamics, Rayner Joel, Longman Publishers
5. Basic Engineering Thermodynamics, Zemanski and Van ness, TMH
6. Fundamentals of Heat and Mass Transfer, F. P. Incropera and D. P. DeWitt, Wiley India Pvt. Ltd.
7. Heat Transfer, 9th ed., J P Holman, McGraw Hill
8. Fundamentals of Engineering Heat and Mass Transfer, 4th ed., R C Sachdeva, New Age International
9. Comprehensive Heat Transfer, M M Rathod, Laxmi Publications
10. Principles of Heat Transfer, Srinivasan D, New Age International
11. Heat Transfer, 2nd ed., A F Mills and V Ganesan, PEARSON
12. Principles of Heat Transfer, 6th ed., Frank Kreith, CENGAGE Learning
13. Heat Transfer, S P Sukhatme, University Press
14. Engineering Heat Transfer, N V Suryanarayana, Penram Publication
15. Heat Transfer, Y V C Rao, University Press

CLASS: SE (Mechatronics)	Subject Code: MTC303	Semester:-III	
SUBJECT: Engineering Materials and Metallurgy			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. FEC103 Applied Chemistry-I
2. FEC203 Applied Chemistry -II

Objectives:

1. To prepare the students understand basic engineering materials, their properties & selection and applications.
2. To familiarize the students with various types and causes of failure of components in different engineering applications.
3. To acquaint the students with the new concepts of Nano Science and Technology.
4. To prepare the students acquire basic understanding of advanced materials, their functions and properties for technological applications.

Outcomes: Learner will be able to...

1. Distinguish different types of materials and composites used in manufacturing.
2. Select a material for specific applications
3. Read and interpret Iron-Iron Carbide phase diagram, TTT diagram and CCT diagram.
4. Demonstrate a deeper understanding of materials in engineering applications.

Modules	Details	Hrs.
01	<p>1.1 Introduction: Classification of materials, functional classification and classification based on structure.</p> <p>1.2 Solidification of Metals: Formation of solids from liquids of pure metals and alloys. Single crystal and polycrystalline structure.</p> <p>1.3 Crystal Imperfection: Definition, classification, Point defects: their formation and effects. Dislocations: Edge and screw dislocations, their significance. Surface defects: Grain boundary, sub-angle grain boundary, stacking fault, and their significance.</p>	07
02	<p>2.1 Fracture: Definition and types of fracture. Brittle fracture and Ductile fracture. Ductility transition.</p> <p>2.2 Fatigue Failure: Definition of fatigue and significance of cyclic stress. Mechanism of fatigue. Fatigue testing. Test data presentation. S.N. Curve and its interpretation. Influence of important factors on fatigue.</p> <p>2.3 Creep: Definition and significance of creep. Effect of temperature and creep on mechanical behavior of materials. Creep testing and data presentation & analysis. Mechanism and types of creep.</p>	07
03	<p>3.1 Ferrous Metals and Alloys: The Iron-Iron Carbide Phase Diagram. Classification of Plain Carbon Steels and Cast Irons. Effect of alloying elements in steels. TTT diagram & CCT diagram. Annealing, normalizing, tempering, hardening and surface hardening processes.</p>	12

	<p>3.2 Nonferrous Metals and Alloys: Basic treatment only. Important nonferrous materials like aluminium, copper, nickel, tin, zinc and their alloys, properties and applications.</p> <p>3.3 Powder Metallurgy: Powder manufacturing methods; Powder Metallurgy Process. Applications such as oil impregnated Bearings and Cemented Carbides. Limitations of Powder Metallurgy.</p>	
04	<p>4.1 Electronic Materials: Band structure of solids. Conductivity of metals and alloys. Semiconductors and superconducting materials. Insulators and dielectric properties. Electrostriction, piezoelectricity and ferroelectricity.</p> <p>4.2 Photonic Materials: Refraction, reflection, absorption and transmission. Luminescence, Photoconductivity, Lasers, optical fibers in communications.</p> <p>4.3 Magnetic Materials: classification of magnetic materials. Diamagnetic, paramagnetic, ferromagnetic, ferrimagnetic and super paramagnetic materials. Metallic and ceramic magnetic materials. Applications of magnetic materials.</p>	08
05	<p>5.1 Ceramics: Definition, comparative study of structure and properties of Engineering Ceramics with reference to metallic materials. Toughening mechanisms in ceramics. Engineering application of Ceramics.</p> <p>5.2 Polymers: Classification of polymers. Thermoplastics, effect of temperature on thermoplastics, mechanical properties of thermoplastics. Thermosetting polymers and elastomers.</p>	08
06	<p>6.1 Composites: Definition; Classification; Particle-reinforced composites and fibre-reinforced composites. Rule of mixtures; Sandwich structures. Classification of composites on basis of matrix materials.</p> <p>6.2 Nano-structured Materials: Definition and Introduction to nano-technology. Unique features of nano-structured materials. Typical applications.</p> <p>6.3 Modern Engineering Materials: Smart materials, Shape memory alloys, Chromic materials (Thermo, Photo and Electro), Rheological fluids, Metallic glasses.</p>	10

Theory Examination:

1. Question paper will comprise of total 06 questions, each of 20 marks.
2. Only 04 questions need to be solved.
3. Question 01 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).

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

Internal Assessment:

Assessment consists of two tests out of which; one should be a 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.

References:

1. *The Science and Engineering of Materials (6th Edition)*, by Donald R. Askeland, Pradeep P. Fulay, Wendelin J. Wright, Cengage Learning, Inc., Stamford, USA., (2010)
2. *Materials Science and Engineering: An Introduction (8th Edition)*, by William D. Callister, Jr. – Adapted by R. Balasubramaniam. Wiley India (P) Ltd., (2010).
3. *Introduction to Physical Metallurgy (2nd Edition)*, by S H Avner, Tata McGraw Hill (1997).
4. *A Text Book of Nanoscience and Nanotechnology*, by Pradeep.T, Tata McGraw Hill, New Delhi, (2012).
5. *Material Science*, by S.L. Kakani, New Age International, (2006).
6. *Electronic Properties of Materials (4th Edition)*, by Rolf.E. Hummel, Springer, New York, (2011).
7. *Photonic Crystals: Theory, Applications, and Fabrication*, by Dennis W Prather, John Wiley & Sons, Hoboken, (2009).

CLASS: SE (Mechatronics)	Subject Code: MTC304	Semester:-III	
SUBJECT: Digital Electronics			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. FEC105 Basic Electrical & Electronics Engineering

Objectives:

1. To teach fundamental principles of digital circuit design
2. To impart the knowledge of programmable devices

Outcomes: Learner will be able to..

1. develop a logic and apply it to solve real life problems
2. design combinational and sequential digital logic circuits
3. demonstrate an understanding of logic families TTL and CMOS
4. Use hardware description languages for logic circuit design and program PLDs.

Module	Detailed contents	Hrs.
1.0	<p>Fundamentals of Digital Design</p> <p>1.1 Logic Gates: Basic gates, Universal gates, Sum of products and products of sum, minimization with Karnaugh Map (upto four variables) and realization.</p> <p>1.2 Logic Families: Types of logic families (TTL and CMOS), characteristic parameters (propagation delays, power dissipation, Noise Margin, Fan-out and Fan-in), transfer characteristics of TTL NAND, Interfacing CMOS to TTL and TTL to CMOS.</p> <p>1.3 Combinational Circuits using basic gates as well as MSI devices: Half adder, Full adder, Half Subtractor, Full Subtractor, multiplexer, demultiplexer, decoder, Comparator (Multiplexer and demultiplexer gate level upto 4:1). MSI devices IC7483, IC74151, IC74138, IC7485.</p>	12
2.0	<p>Elements of Sequential Logic Design :</p> <p>2.1 Sequential Logic: Latches and Flip-Flops, Conversion of flip flops (timing considerations and metastability are not expected)</p> <p>2.2 Counters: Asynchronous, Synchronous Counters, Up Down Counters, Mod Counters, Ring Counters Shift Registers, Universal Shift Register</p>	11
3.0	<p>Sequential Logic Design:</p> <p>3.1 Mealy and Moore Machines, Clocked synchronous state machine analysis, State reduction techniques and state assignment, Clocked synchronous state machine design. (<i>Complex word problems like traffic light controller etc. are not expected</i>)</p> <p>3.2 MSI counters (7490, 74163, 74169) and applications, MSI Shift registers (74194) and their applications.</p>	11
4.0	<p>Memories and Programmable Logic Devices:</p> <p>4.1 Classification and characteristics of memory: SRAM, DRAM, ROM, PROM, EPROM and FLASH memories</p> <p>4.2 Concepts of PAL and PLA. Architecture of CPLD and FPGA, Xilinx XC 9500 CPLD Series and Xilinx XC 4000 FPGA Series.</p>	08

5.0	Simulation: 5.1 Functional Simulation, Timing simulation, Logic Synthesis, RTL 5.2 VHDL: Data types, Structural Modeling using VHDL, attributes, data flow, behavioral, VHDL implementation of basic combinational and sequential Circuits.	06
6.0	Testability: Fault Models, Stuck at faults, ATPG, Design for Testability, Boundary Scan Logic, JTAG and Built in self test.	04
		52

Internal Assessment (IA):

Assessment consists of two tests out of which; one should be a 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 06 questions, each of 20 marks.
2. Only 04 questions need to be solved.
3. Question 01 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).

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

References:

- William I. Fletcher, 'An Engineering Approach to Digital Design', PHI.
- B. Holdsworth and R. C. Woods, 'Digital Logic Design', Newnes, 4th Edition
- Morris Mano, Digital Design, Pearson Education, Asia 2002.
- John F. Wakerley, Digital Design Principles And Practices, third Edition Updated, Pearson Education, Singapore, 2002
- Anil K. Maini, Digital Electronics, Principles, Devices and Applications, Wiley
- Stephen Brown and Zvonko Vranesic, Fundamentals of digital logic design with VHDL, McGraw Hill, 2nd Edition

CLASS: SE (Mechatronics)	Subject Code: MTC305	Semester:-III	
SUBJECT: Applied Electrical and Electronics 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

Prerequisite:

1. FEC102 Applied Physics
2. FEC105 Basic Electricity and Electronics

Objectives:

1. Understand working and performance of electrical and electronic devices
2. Applications of electrical and electronic devices.

Outcomes: Learner will be able to...

1. Analyze second order systems in time and frequency domain
2. Illustrate working and performance characteristics of DC Motors
3. Illustrate working and performance characteristics of three phase Induction Motor
4. Implement systems using low power motors like stepper motor, brushless DC Motor and single phase induction motor
5. Illustrate working of Junction Transistors as switch

Module	Detailed contents	Hrs.
1	Time Domain Analysis of RLC circuits 1.1 Time domain analysis of R-L and R-C circuits: Forced and natural response, time constant, initial and final values 1.2 Solution using first order equation for standard input signals: Transient and steady state time response, solution using universal formula 1.3 Time domain analysis of R-L-C circuits: Second order forced and natural response and concept of damping	08
2	Frequency domain analysis of RLC circuits 2.1 S-domain representation, applications of Laplace Transform in solving electrical networks, driving point and transfer function, 2.2 Poles and Zeros, calculation of residues by analytical and graphical method 2.3 Frequency response	08
3	Junction Transistors as Switch 3.1 Junction Field Effect Transistor JFET: Construction, pinch off voltage, transfer characteristic, trans-conductance 3.2 Metal-Oxide Effect Transistor (MOSFET): Working of MOSFET, threshold voltage and MOSFET as switch 3.3 BJT: Regions of operation, normally ON and normally OFF state biasing, working of BJT CE amplifier and BJT as a switch	10
4	DC Motors 4.1 Construction, principle of working, significance of commutator and brushes in DC machine, classification EMF equation, Torque equation, characteristics of DC Motors 4.2 Starters for shunt and series motors 4.3 Speed Control: basic principle and working of different methods	08

5	Three Phase Induction Motor 5.1 Construction, working principle of squirrel cage induction motor 5.2 Equivalent circuit: Equivalent circuit development, torque speed characteristics, power 5.3 Speed control methods 5.4 Starting methods: Classification and working of different methods	10
6	Low Power Motors 6.1 Brushless DC Motors: Unipolar brushless DC motor, Bipolar brushless DC motor, speed control, important features and applications 6.2 Stepper Motors: Constructional features, working principle and applications 6.3 Single phase Induction Motors: construction, working, starting methods, tor-speed characteristics and applications	08
Total		52

Internal Assessment (IA):

Assessment consists of two tests out of which; one should be a 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 06 questions, each of 20 marks.
2. Only 04 questions need to be solved.
3. Question 01 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).

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

References:

1. M E Van Valkenburg, "*Network Analysis*", Prentice-Hall of India Pvt Ltd, New Delhi
2. Donald A. Neamen, "*Electronic Circuit Analysis and Design*", TATA McGraw Hill, 2nd Edition, New Delhi
3. Bimbhra P.S., "*Electric Machinery*", Khanna Publisher, New Delhi
4. M. A. Mazadi and J. C. Mazadi, "*The 8051 Microcontroller and Embedded Systems*", Pearson Education, New Delhi
5. John Uffenbeck, "*8086/8088 family: Design Programming and Interfacing*", Pearson Education, New Delhi

CLASS: SE (Mechatronics)	Subject Code: MTL306	Semester:-III
SUBJECT: Computer Aided Machine Drawing		Credit: 3
*Theory for entire class to be conducted	*Theory	*02 hours per week
Practical to be conducted for batch of students	Practical	04 hours per week

Pre-requisites:

1. FEC 204 Engineering Drawing

Objectives:

1. To visualize an object and convert it into a drawing.
2. To gain knowledge of conventional representation of various machining and mechanical details as per IS.
3. To become conversant with 2-D and 3-D drafting.

Outcomes: Learner should be able to....

1. Visualize and prepare detail drawing of a given object.
2. Draw details and assembly of mechanical systems.
3. Read and interpret a given machine drawing.
4. Create 2-D and 3-D models using any standard CAD software with manufacturing considerations.

Module	Details	Hrs.	
		Th.	Pract
1	1.1 Solid Geometry: Intersection of surfaces and interpenetration of solids- Intersection of prism or cylinder with prism; cylinder or cone, both solids in simple position only. Primary auxiliary views and auxiliary projections of simple machine parts.	08	--
	1.2 Machine Elements: Preparation of 2-D drawings of standard machine elements (nuts, bolts, keys, cotter, screws, spring etc.)	--	06
	1.3 Conventional representation of assembly of threaded parts in external and sectional views, Types of threads; thread designation, Conventional representation of machine components and materials, Designation of standard	01	--

2	2.1 Limits fits and tolerances: Dimensioning with tolerances indicating various types of fits in details and assembly drawings, Types of assembly drawings, part drawings, drawings for catalogues and instruction manuals, patent drawings, drawing standards.	04	--
	2.2 Details and assembly drawing: Introduction to the unit assembly drawing, steps involved in preparing assembly drawing from details and vice-versa, Sequence in assembly.	02	--
	2.3 Preparation of details and assembly drawings of <i>any two</i> from: Clapper block, Single tool post, Lathe and Milling tail stock.	--	06
	2.4 Cotter, Knuckle joint, Keys and Couplings: keys-sunk, parallel woodruff, saddle, feather etc. Coupling: simple, muff, flanged.	03	--
3	3.1 Preparation of details and assembly drawings of Bearings: Simple, solid, Bushed bearing. I.S. conventional representation of ball and roller bearing.	01	06
	3.2 Pedestal bearing, footstep bearing		
4	4.1 Preparation of details and assembly drawings of pulleys, Pipe joints: Classification of Pulleys, pipe joints	02	--
	4.2 Pulleys: Flat belt, V-belt, rope belt, Fast and loose pulleys.	--	06
	4.3 Pipe joints (any two): Flanged joints, Socket and spigot joint, Gland and stuffing box, expansion joint.	--	06
5	5.1 Preparation of details and assembly drawings of Valves, I.C. Engine parts: Types of Valves, introduction to I.C. Engine	02	--
	5.2 Preparation of details and assembly drawings of (any three): Air cock; Blow off cock, Steam stop valve, Gate valve, Globe valve, Non return Valve, I.C. Engine parts: Piston, Connecting rod, Cross head, Crankshaft,	--	08
6	6.1 Preparation of details and assembly drawings of Jigs and Fixtures: Introduction to Jigs and fixtures.	01	--
	6.2 Jigs and Fixtures (<i>any two from each</i>)	--	06
	6.3 Reverse Engineering of a physical model: disassembling of any physical model having not less than five parts, sketch the minimum views required for each component, measure all the required dimensions of each component, convert these sketches into 3-D model and create an assembly drawing with actual dimensions.	--	06

Term work:

- A. Minimum two questions from theory part of each module should be solved as a home work in A-3 size sketch book.
- B. A-3 size Printouts/plots of the problems solved in practical class from the practical part of each module

Problems from practical parts of each module should be solved using any standard CAD packages like IDEAS, PRO-E, CATIA, Solid Works, Inventor etc.

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

Home work sketch book	.....	20 marks
Printouts/Plots	.....	20 marks
Attendance (Theory and practical's)	.....	10 marks

Practical/Oral examination:

1. Practical examination duration is **three hours**, based on Part-B of the Term work, and should contain two sessions as follows:

Session-I: Preparation of 3-D models of parts, assembling parts and preparing views of assembly from given 2-D detailed drawing.

Session-II: Preparation of minimum five detailed 3-D part drawings from given 2-D assembly drawing.

Oral examination should also be conducted to check the knowledge of conventional and CAD drawing.

2. Questions provided for practical examination should contain minimum five and not more than ten parts.
3. The distribution of marks for practical examination shall be as follows:

Session-I	..... 20marks
Session-II	..... 20marks
Oral	.....10 marks
4. Evaluation of practical examination to be done based on the printout of students work
5. Students work along with evaluation report to be preserved till the next examination

References:

1. Machine Drawing by N.D. Bhatt.
2. A text book of Machine Drawing by Laxminarayan & M.L. Mathur. (Jain brothers Delhi).
3. Machine Drawing by Kamat & Rao.
4. Machine Drawing by M.B. Shah
5. A text book of Machine Drawing by R.B. Gupta (Satyaprakashan, Tech. Publication)
6. Machine Drawing by K.I. Narayana, P. Kannaiah, K. Venkata Reddy.
7. Machine Drawing by Sidheshwar and Kanheya
8. Autodesk Inventor 2011 for Engineers and Designers by Sham Tickoo, Surinder Raina (dreamtech Press).
9. Engineering Drawing by P J Shah
10. Engineering Drawing by N D Bhatt

CLASS: SE (Mechatronics)	Subject Code: MTL307	Semester:-III
SUBJECT: Object Oriented Programming Laboratory		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 practical per batch per week

Pre-requisites:

1. FEC 205 Structured Programming Approach

Objectives:

1. To study the concepts of Object oriented programming.
2. To study solving of the real world problem using top down approach.
3. To study Java programming constructs.

Outcomes: Learner will be able to...

1. Solve basic computational problems using Java programming constructs like if-else, control structures, array and strings.
2. Model real world scenario using class diagram.
3. Exhibit communication between two objects.
4. Implement relationships between classes.
5. Demonstrate programs on exceptions, multithreading.

Module	Detailed Contents	Th. Hours
1	Introduction to Object Oriented Programming 1.1 Principle of Object Oriented Programming 1.2 Differences and similarity between C++ and Java 1.3 Advantages of object oriented programming	04
2	Java Fundamentals 2.1 Features of Java 2.2 Introduction to Java Environment ,JDK, 2.3 Structure of a Java Program 2.4 Looping and Methods 2.5 Developing a simple Java Program	06
3	Java classes and objects 3.1 Arrays, Vectors ,Strings and Wrapper classes 3.2 Constructor and Finalize 3.3 Parameterized Methods and classes 3.4 Exception Handling 3.5 I/O Processor	08
4	Inheritance 4.1 Understanding Inheritance 4.2 Forms of Inheritance 4.3 Super and Final Key words 4.4 Abstract classes and Interfaces 4.5 Multithreading and Packaging	08

Term Work:**Term work shall consist of**

1. Minimum two assignments covering the entire syllabus.
2. Minimum 10 experiments and one mini project (in a group of maximum three) covering entire syllabus should be set to have well predefined inference and conclusion.

Term Work Evaluation: 50 Marks (Total marks) = 30 Marks (Experiment) +10 Marks (mini project) +10 Marks (Attendance)

The practical and oral examination will be based on entire syllabus.

Practical's:

All the programs and mini project should be implemented in Java under Windows, Linux or Ubuntu environment.

References:

1. E Balgurusamy, "*Programming with JAVA*", Tata McGraw Hill
2. G. T. Thampi, "*Object Oriented Programming in Java*", Dream Tech Press
3. Herbert Schildt, "*The Complete Reference JAVA*", Tata McGraw Hill

CLASS: SE (Mechatronics)	Subject Code: MTL308	Semester:-III
SUBJECT: Applied Electronics Laboratory-I		Credit: 1
Practical to be conducted for batch of students	Practical	Slot of 02 hours per week

Prerequisite:

1. FEC102 Applied Physics
2. FEC105 Basic Electricity and Electronics

Objectives:

1. Characterization of electrical and electronics circuits
2. Characterization of electrical and electronics actuators

Outcomes: Learner will be able to..

1. analyze second order systems in time and frequency domain
2. characterize TTL family
3. characterize MOS family
4. Implement combinational and sequential circuits using MSI devices.

List of experiments:

1. Time domain response of RC circuit
2. Time domain response of R-L-C series circuit: under, over and critically damped. This can be studied by writing a simple programme using any software tool. Plot time domain response and study effect of change in values of R-L-C
3. Write a simple programme for the transfer function of any R-L-C circuit. Plot frequency domain response and study effect of change in values of R-L-C
4. Speed control of DC shunt and series motor
5. Plot torque speed characteristics of DC shunt motor
6. Speed control of three phase Induction Motor
7. Stepper Motor control
8. Starting of capacitor start/run single phase Induction Motor
9. BJT as electronic ON/OFF switch
10. JFET as electronic ON/OFF switch
11. MOSFET as electronic ON/OFF switch
12. Developing ON/OFF control for Stepper Motor
13. Developing ON/OFF control for permanent magnet DC motor

Term Work:

Term work shall consist of minimum 10 experiments and should be set to have well predefined inference and conclusion.

Term Work Evaluation: 25 Marks (Total marks) = 20 Marks (Experiment) +05 Marks (Attendance)

Practical / Oral Examination:

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

The distribution of marks for oral-practical examination shall be as follows:

Practical Examination 15 marks
Oral 10 Marks

1. Evaluation of practical examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.

CLASS: SE (Mechatronics)	Subject Code: MTL309	Semester:-III
SUBJECT: Engineering Materials and Metallurgy Laboratory		Credit: 1
Practical to be conducted for batch of students	Practical	Slot of 02 hours per week

Pre-requisites:

1. FEC103 Applied Chemistry-I
2. FEC202 Applied Physics –II
3. FEC203 Applied Chemistry –II

Objectives:

1. To prepare the students understand basic engineering materials, their properties & selection and applications.
2. To prepare the students acquire basic understanding of advanced materials, their functions and properties for technological applications.

Outcomes: Learner will be able to...

1. Distinguish different types of materials and composites used in Manufacturing.
2. Demonstrate a deeper understanding of heat treatment processes for engineering applications.
3. perform non-destructive technique (NDT)

List of Experiments:

1. Preparation of specimen (minimum two metals/alloys) for microscopic examination.
2. Heat treatment process (Annealing, Normalizing and Hardening).
3. Jominy end Quench test for hardenability.
4. NDT (at least two).

Term Work:

Term work shall consist of

1. Assignments: On topics drawn from syllabus.
2. Factory report: Preparation of equipment, process, quality control and failure analysis of engineering components reports after visit to important industrial plants.
3. All experiments mentioned in the list of experiments shall be performed.

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

- Laboratory work (assignments, Practicals): 10 Marks.
- Report on Factory visit: 10 Marks
- Attendance (Practicals): 05 Marks.

TOTAL: 25 marks

CLASS: SE (Mechatronics)	Subject Code: MTC401	Semester:-IV	
SUBJECT: Applied Mathematics IV			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-requisites:

1. FEC101 Applied Mathematics-I
2. FEC201 Applied Mathematics-II

Objectives:

1. To inculcate an ability to relate engineering problems to mathematical context.
2. To provide a solid foundation in mathematical fundamentals required to solve engineering problem.
3. To study the basic principles of Vector analyses, statistics and probability and complex integration.
4. To prepare students for competitive exams.

Outcomes: Learner will be able to

1. Use matrix algebra with its specific rules to solve the system of linear equations.
2. Understand and apply the concept of probability distribution and sampling theory to engineering problems.
3. Apply principles of vector differential and integral calculus to the analysis of engineering problems.
4. Identify, formulate and solve engineering problems.

Module	Details	Hrs
1	Matrices 1.1 Brief revision of vectors over a real field, inner product, norm, Linear Dependence and Independence and orthogonality of vectors. 1.2 Characteristic polynomial, characteristic equation, characteristic roots and characteristic vectors of a square matrix, properties of characteristic roots and vectors of different types of matrices such as orthogonal matrix, Hermitian matrix, Skew-Hermitian matrix, Cayley Hamilton theorem (without proof) Functions of a square matrix, Minimal polynomial and Derogatory matrix.	09
2	Vector calculus 2.1 Brief revision of Scalar and vector point functions, Gradient, Divergence and curl. 2.2 Line integrals, Surface integrals, Volume integrals. Green's theorem (without proof) for plane regions and properties of line integrals, Stokes theorem (without proof), Gauss divergence theorem (without proof) related identities and deductions. (No verification problems on Stoke's Theorem and Gauss Divergence Theorem)	11

3	<p>Non Linear Programming</p> <p>3.1 Unconstrained optimization, problems with equality constraints Lagranges Multiplier method.</p> <p>3.2 Problem with inequality constraints Kuhn-Tucker conditions.</p>	06
4	<p>Probability Distributions</p> <p>4.1 Discrete and Continuous random variables, Probability mass and density function, Probability distribution for random variables, Expected value, Variance.</p> <p>4.2 Probability Distributions: Binomial, Poisson and Normal Distributions for detailed study.</p>	10
5	<p>Sampling Theory</p> <p>5.1 Sampling distribution. Test of Hypothesis. Level of significance, critical region. One tailed and two tailed tests. Interval Estimation of population parameters. Large and small samples.</p> <p>5.2 Test of significance for Large samples: Test for significance of the difference between sample mean and population means, Test for significance of the difference between the means of two samples.</p> <p>5.3 Student's t-distribution and its properties. Test of significance of small samples: Test for significance of the difference between samples means and population means, Test for significance of the difference between the means of two Samples, paired t-test.</p> <p>5.4 Analysis of Variance(F-Test): One way classification, Two-way classification(short-cut method)</p> <p>5.5 Chi-square distribution and its properties, Test of the Goodness of fit and Yate's correction.</p>	10
6	<p>Correlation and Regression</p> <p>6.1 Correlation, Co-variance, Karl Pearson Coefficient of Correlation & Spearman's Rank Correlation Coefficient (non-repeated & repeated ranks)</p> <p>6.2 Regression Coefficients & lines of regression</p>	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 Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

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

References:

1. Fundamentals of Mathematics Statistics, S C Gupta & V K Kapoor, S. Chand & Co
2. Higher Engineering Mathematics, Dr B. S. Grewal, Khanna Publication
3. Elements of Applied mathematics, P N & J N Wartikar, Pune VidyarthiGruhaPrakashan
4. Advanced Engineering Mathematics, E Kreyszing, Wiley Eastern Limited
5. Operations Research, S.D. Sharma, S. Chand & CO.
6. Vector Analysis by Murray R. Spiegel, Shaum Series
7. Operations Research, Kantiswarup, Manmohan, P K Gupta, S. Chand & CO.

CLASS: SE (Mechatronics)	Subject Code: MTC402	Semester:-IV	
SUBJECT: Kinematics 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-requisites:

1. FEC104 Engineering Mechanics

Objectives:

1. To provide basic concepts of kinematics of machine elements.
2. To understand velocity and acceleration analysis of mechanisms.
3. To study basics of power transmission by belts, chains, gears.
4. To analyse cam and follower mechanisms.

Outcomes: Learner should be able to...

1. Define various components of mechanisms.
2. Construct/Compose mechanisms to provide specific motion.
3. Draw velocity and acceleration diagrams.
4. Select appropriate power transmission mechanism.
5. Construct cam profile for the specific follower motion.

Sr. no.	Details	Hrs
1	<p>1.1 Kinetics of Rigid Bodies D'Alemberts Principle, Application of motion of bars, cylinders and spheres only. Kinetics of Rigid Bodies: Kinetic energy in translating motion, Rotation about fixed axis and in general plane motion.</p> <p>1.2 Basic Kinematics: Kinematic link, Types of links, Kinematic pair, Types of constrained motions, Types of Kinematic pairs, Kinematic chain, Types of joints, Mechanism, Machine, Degree of freedom (Mobility), Kutzbach criterion, Grubler's criterion Four bar chain and its inversions, Double slider crank chain and its inversions.</p>	07
2	<p>Mechanisms: Straight line generating Mechanisms: Exact Straight Line Generating Mechanisms –Peaucellier approximate Straight Line Generating Mechanisms – Watt, Grasshopper and Tchebicheff's. Compliant mechanisms, Flexure based straight line mechanism. Offset slider crank mechanisms, Pantograph, Overview of mechanisms used in mechatronics systems: image scanner, 3D printer.</p>	08
3	<p>Velocity & Acceleration analysis of Mechanisms 3.1 Velocity Analysis of mechanisms (mechanisms up to 6 links). Velocity analysis by instantaneous center of rotation method (Graphical approach) Velocity analysis by relative velocity method (Graphical approach) Analysis is extended to find rubbing velocities at joints, mechanical advantage (Graphical approach). Velocity analysis of low</p>	09

	<p>degree complexity mechanisms (Graphical approach). Auxiliary point method</p> <p>3.2 Velocity and Acceleration analysis of mechanism.</p> <p>Velocity and Acceleration –analysis by relative method (mechanisms up to 6 link) including pairs involving Coriolis acceleration (Graphical Approach).</p>	
4	<p>Synthesis of Mechanisms and linkages: Classification of Synthesis Problem, precision points for function Generation, Graphical synthesis of four bar mechanism, Three position synthesis, Four point synthesis, coupler-curve synthesis, Graphical synthesis of slider crank mechanism, Least square technique, Synthesis of four bar mechanism for body guidance.</p>	10
5	<p>Belts and Chains</p> <p>5.1 Belt –Types of belts, velocity ratio, slip & creep, length of belt for open & cross system. Law of belting, Dynamic analysis- driving tensions, centrifugal tension, initial tension, condition of maximum power transmission.</p> <p>5.2 Chains –types of chains, chordal action, variation in velocity ratio, Length of chain.</p> <p>5.3 Gears</p> <p>Law of gearing, Involute and Cycloid gear tooth profile, Construction of Involute profile. Path of contact, arc of contact, contact ratio for involutes and cycloidal tooth profile, Interference in involutes gears. Critical Numbers of teeth for interference free motion. Static force analysis in gears- spur, helical, worm & worm wheel.</p> <p>5.4 Gear Trains</p> <p>Kinematics and dynamic analysis of - simple gear trains, Module compound gear trains, reverted gear trains, epicyclic gear trains with spur or bevel gear combination.</p>	10
6	<p>Cams and Followers</p> <p>Cam and its Classifications.</p> <p>Followers and its Classification.</p> <p>Motion analysis and plotting of displacement-time, velocity-time, acceleration- time, jerk-time graphs for uniform velocity. UARM, SHM.</p> <p>Motion analysis of simple cams –R-R cam, D-R-R and D-R-D-R cam operating radial translating follower.</p> <p>Layout of cam profiles.</p>	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 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 Mechanisms and Machines by Amitabh Ghosh and A. Kumar Mallik.
2. Theory of Machines and Mechanism by John Uicker, Garden Pennock & Late. J. F. Shigley
3. Theory of Machines –P. L. Ballaney
4. Theory of Machines by S. S. Rattan
5. Kinematics of Machines by R T Hinckle (Prentice Hall Inc.)
6. Kinematics By V.M. Fairs (McGraw Hill)
7. Mechanism Design: Analysis and Synthesis Vol. I by A. Erdman and G.N. Sander (Prentice Hall)
8. Kinematics and Dynamics of Planer Mechanisms by Jeremy Hirsihham (McGraw Hill).

CLASS: SE (Mechatronics)		Subject Code: MTC403		Semester:-IV	
SUBJECT: Fluid Mechanics and 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-requisites:

1. FEC104 Engineering Mechanics

Objectives:

1. To study the properties of the fluids.
2. To study the dynamics of fluids.
3. To study the transport of mass, momentum and energy.
4. To study the applications of the conservation laws to flow through pipes and hydraulics machines.

Outcomes: Learner will be able to...

1. Illustrate the physical properties and characteristic behavior of fluids.
2. Illustrate the principle and applications of continuity equation.
3. Learn about the Euler's equations along the streamlines.
4. Apply the principles of turbulent Vs laminar flow to flow systems
5. Apply the concepts of friction and determine friction factors.
6. Illustrate dimensional analysis for model and similitude of hydraulic machines.
7. Illustrate the working principle of hydraulic turbines.
8. Illustrate the working principle of hydraulic pump.

Module	Details	Hrs
01	INTRODUCTION: Units & Dimensions. Properties of fluids – Specific gravity, specific weight, viscosity, compressibility, vapour pressure and gas laws – capillarity and surface tension. Flow characteristics: concepts of system and control volume. Classification of fluids - Properties of fluids. Centre of pressure - Plane and curved surfaces. Buoyancy and stability of floating bodies.	9
02	FLUID KINEMATICS AND FLUID DYNAMICS: Fluid kinematics: stream line, path line and streak lines and stream tube, classification of flows-steady & unsteady, uniform, non uniform, laminar, turbulent, rotational, and irrotational flows-equation of continuity for one dimensional flow. Fluid dynamics: surface and body forces –Euler's and Bernoulli's equations for flow along a stream line, Bernoulli's equation - applications - Venturi meter – Orifice meter Pitot tube. Momentum equation and its application on force on pipe bend. Applications of momentum equations.	8
03	INCOMPRESSIBLE FLUID FLOW: Viscous flow - Shear stress, pressure gradient relationship - laminar flow between parallel plates - Laminar flow through circular conduits and circular annuli. Boundary layer concepts. Boundary layer thickness. Hydraulic and energy gradient. Darcy – Weibach equation. Friction factor and Moody diagram. Commercial pipes. Minor losses. Flow through pipes in series and in parallel.	9

04	DIMENSIONAL ANALYSIS: Dimension and units: Buckingham's Π theorem. Discussion on dimensionless parameters. Models and similitude. Applications of dimensionless parameters. Model analysis Dimensionless number and their significance, model laws, Reynold's model law, Fraude's model law, Euler's model law, Weber's model law, Mach's Model law, Type of models, scale effect in model, limitation of hydraulic similitude.	8
05	HYDRAULIC TURBINES: Hydro turbines: Definition and classification, turbines, impulse and reaction turbines, Pelton wheel, Francis turbine and Kaplan turbine - working proportions, work done, efficiencies, hydraulic design -draft tube- theory- functions and efficiency.	9
06	HYDRALUIC PUMPS: Pumps: definition and classifications - Centrifugal pump; classifications, working principle, velocity triangles, Work done - Reciprocating pump: classification, working principle, Basic principles of indicator diagram. Performance parameters and characteristics of pumps and turbines; Positive displacement pumps.	9

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. Frank M. White, 1999, Fluid Mechanics, 4e, McGraw-Hill.
2. Streeter V.L., and Wylie, E.B., "Fluid Mechanics", 4th Edition, McGraw-Hill, 1983.
3. Babu.V "Fundamentals of Incompressible Flow", CRC press, First Edition, 2010.
4. White F.M., "Fluid Mechanics", 5th Edition, Tata McGraw-Hill, New Delhi, 2003.
5. Som S.K., and Biswas, G., "Introduction to Fluid Mechanics and Fluid Machines", 2nd Edition, Tata McGraw-Hill, 2004.
6. Vijay Gupta, Santhosh Kumar Gupta, "Fluid Mechanics and it applications", New Age International Publishers, 2nd Edition, 2011.
7. Kumar. K.L., Engineering Fluid Mechanics (VII Ed.) Eurasia Publishing House (P) Ltd., New Delhi, 1995.
8. Bansal, R.K., Fluid Mechanics and Hydraulics Machines, Laxmi Publications (P) Ltd., New Delhi.

CLASS: SE (Mechatronics)	Subject Code: MTC404	Semester:-IV	
SUBJECT: Strength of Material			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-requisites:

1. FEC104 Engineering Mechanics
2. MTC 303 Engineering Materials and Metallurgy

Objectives:

1. To gain knowledge of different types of stresses, strain and deformation induced in the mechanical components due to external loads.
2. To study the distribution of various stresses in the mechanical elements such as beams, shafts etc.
3. To study Effect of component dimensions and shape on stresses and deformations.

Outcomes: Learner will be able to

1. Demonstrate fundamental knowledge about various types of loading and stresses induced.
2. Draw SFD and BMD for different types of loads and support conditions.
3. Compute and analyze stresses induced in basic mechanical components.
4. Analyze buckling and bending phenomenon in columns and beams respectively.

Module	Details	Hrs
1	<p>Moment of Inertia: Mass Moment of Inertia , Area Moment of Inertia, Parallel Axis theorem, Polar Moment of Inertia, Principal axes, Principal moment of inertia.</p> <p>Stress and Strain: Definition, Stress- strain, uni-axial, bi-axial and tri-axial stresses, tensile & compressive stresses, shear stress-Elastic limit, Hooke's Law.</p> <p>Elastic Constants: Poisson's Ratio, Modulus of elasticity, Modulus of rigidity, Bulk modulus, Yield stress, Ultimate stress. State of simple shear, relation between elastic constants, Volumetric strain, Volumetric strain for tri-axial loading, Deformation due to self-weight, Stresses in bars of varying sections, composite sections. Thermal Stress.</p>	7
2	<p>Stresses Analysis: General case of two-dimensional stress, Principal Stresses, Directions of Principal Stresses; Principal Planes, Shearing Stresses on Principal Planes, Maximum Shearing Stresses, Normal Stresses on Planes of Maximum Shearing Stress, Mohr's Circle, Determination of Principal Stresses by Mohr's Circle, Determination of Stresses on Arbitrary plane by Mohr's Circle. Principal Stresses for a General State of Stress, Mohr's Circle for General State of stress.</p>	9

3	<p>Shear Force and Bending Moment in Beams:</p> <p>Axial force, shear force and bending moment diagrams for statically determinate beams including beams with internal hinges for different types of loading, relationship between rates of loading, shear force and bending moment.</p>	9
4	<p>Stresses in Beams:</p> <p>Theory of pure Bending, Assumptions, Flexural formula for straight beams, moment of resistance, bending stress distribution, Section moduli for different sections, beams for uniform strength, Flitched beams.</p> <p>Direct & Bending Stresses:</p> <p>Core of Section, Chimneys subjected to wind pressure</p> <p>Shear Stress in Beams:</p> <p>Distribution of shear stress, across plane sections used commonly for structural purposes, shear connectors.</p>	9
5	<p>Torsion:</p> <p>Torsion of circular shafts-solid and hollow, stresses in shafts when transmitting power, shafts in series and parallel.</p> <p>Strain Energy:</p> <p>Resilience, proof Resilience, strain energy stored in the member due to gradually applies load, suddenly applied load, impact load. Strain energy stored due to Shear, Bending and Torsion.</p>	9
6	<p>Deflection of Beams:</p> <p>Deflection of Cantilever, simply supported and over hanging beams using double integration and Macaulay's Method for different type of loadings.</p> <p>Thin Cylindrical and Spherical Shells:</p> <p>Cylinders and Spheres due to internal pressure. Cylindrical Shell with hemispherical end.</p>	9

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

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

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.

References:

1. Strength of Materials, Subramanyam, Oxford University Press, Edition 2005
2. Mechanics of Materials, B.C Punmia Ashok Jain, Arun Jain, Lakshmi Publications, NewDelhi.
3. Strength of Materials, Basavarajaiah and MahadevappaKhanna Publishers, New Delhi.
4. Strength of Materials, Singer Harper and Row Publications
5. Elements of Strength of Materials, Timoshenko and Young Affiliated East-West Press.
6. Mechanics of Materials, James M. Gere (5th Edition), Thomson Learning
7. Strength of Materials—S. Ramamrutham, DhanpatRai Pvt. Ltd.
8. Mechanics of Materials—S. S. Rattan, TMH Pvt. Ltd.
9. Mechanics of Structures—S. B. Junnarkar, Charotar Publication.
10. Strength of Materials—W. Nash, Schaum's Outline Series, McGraw Hill Publication.

CLASS: SE (Mechatronics)		Subject Code: MTC405		Semester:-IV	
SUBJECT: Application of Integrated Circuits				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

Objectives:

1. To teach fundamental principles of standard linear integrated circuits.
2. To develop a overall approach for students from selection of integrated circuit, study its specification, the functionality, design and practical applications

Outcomes: Learner will be able to..

1. Demonstrate an understanding of fundamentals of integrated circuits.
2. Analyze the various applications and circuits based on particular linear integrated circuit.
3. Select and use an appropriate integrated circuit to build a given application.
4. Design an application with the use of integrated circuit

Module	Topics	Hrs
1	Fundamentals of Operational Amplifier 1.1 Ideal Op Amp, characteristics of op-amp, op-amp parameters, high frequency effects on op-amp gain and phase, slew rate limitation, practical determination of op-amp parameters, single supply versus dual supply op-amp 1.2 Operational amplifier open loop and closed loop configurations, Inverting and non-inverting amplifier	06
2	Linear Applications of Operational Amplifier 2.1 Amplifiers: Adder, subtractor, integrator, differentiator, current amplifier, difference amplifier, instrumentation amplifier and application of Op-Amp in Transducer Measurement System with detail design Procedure. 2.2 Converters: Current to voltage converters, voltage to current converters 2.3 Active Filters: First order filters, Second order active finite and infinite gain low pass, high pass, band pass and band reject filters. 2.4 Sine Wave Oscillators: RC phase shift oscillator and Wien bridge oscillator	12
3	Non-Linear Applications of Operational Amplifier 3.1 Comparators: Inverting comparator, non-inverting comparator, zero crossing detector, window detector and level detector. 3.2 Schmitt Triggers: Inverting and non-inverting Schmitt trigger 3.3 Waveform Generators: Square wave generator and triangular wave generator with duty cycle modulation 3.4 Precision Rectifiers: Half wave and full wave precision rectifiers and their applications. 3.5 Peak Detectors, Sample & Hold Circuits, voltage to frequency converter, frequency to voltage converter, logarithmic converters and antilog converters	12

4	Data Converters 4.1 Analog to Digital: Performance parameters of ADC, Single Ramp ADC, ADC using DAC, Dual Slope ADC, Successive Approximation ADC, Flash ADC, ADC0808/0809 and its interfacing 4.2 Digital to Analog: Performance parameters of DAC, Binary weighted register DAC, R/2R ladder DAC, Inverted R/2R ladder DAC, DAC0808 and its interfacing	06
5	Special Purpose Integrated Circuits 5.1 Functional block diagram, working, design and applications of Timer 555. 5.2 Functional block diagram, working and applications of VCO 566, PLL 565, multiplier 534, waveform generator XR 2206, power amplifier LM380.	08
6	Voltage Regulators 6.1 Functional block diagram, working and design of three terminal fixed (78XX, 79XX series) and three terminal adjustable (LM 317, LM 337) voltage regulators. 6.2 Functional block diagram, working and design of general purpose 723 (LVLC, LVHC, HVLC and HVHC) with current limit and current fold-back protection, Switching regulator topologies, Functional block diagram and working of LT1070 monolithic switching regulator.	08
Total		52

Internal Assessment (IA):

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. The students need to solve total 4 questions.
3. Question No.1 will be compulsory preferably objective type and based on entire syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

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

References:

1. Sergio Franco, "*Design with operational amplifiers and analog integrated circuits*", Tata McGraw Hill, 3rd Edition.
2. William D. Stanley, "*Operational Amplifiers with Linear Integrated Circuits* ", Pearson, 4th Edition
3. D. Roy Choudhury and S. B. Jain, "*Linear Integrated Circuits*", New Age International Publishers, 4th Edition.
4. David A. Bell, "*Operation Amplifiers and Linear Integrated Circuits*", Oxford University Press, Indian Edition.
5. Ramakant A. Gayakwad, "*Op-Amps and Linear Integrated Circuits*", Pearson Prentice Hall, 4th Edition.
6. R. P. Jain, "*Modern Digital Electronics*," Tata McGraw Hill, 3rd Edition.
7. Ron Mancini, "*Op Amps for Everyone*", Newnes, 2nd Edition.
8. J. Millman and A. Grabel, "*Microelectronics*", Tata McGraw Hill, 2nd Edition.
9. R. F. Coughlin and F. F. Driscoll, "*Operation Amplifiers and Linear Integrated Circuits*", Prentice Hall, 6th Edition.
10. J. G. Graeme, G. E. Tobey and L. P. Huelsman, "*Operational Amplifiers- Design & Applications*", NewYork: McGraw-Hill, Burr-Brown Research Corporation.

CLASS: SE (Mechatronics)		Subject Code: MTC406		Semester:-IV	
SUBJECT: Signals and 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. MTC305: Applied Electrical and Electronics Engineering

Objectives:

1. To introduce students to the idea of signal and system analysis and characterization in time and frequency domain.
2. To provide foundation to numerous other courses that deal with signal and system concepts directly or indirectly.

Outcomes: Learner will be able to...

1. Classify various types of signals and systems.
2. Analyze continuous time systems in time domain and Laplace, z , and frequency domains.
3. Explain and apply the properties Laplace transform/ z -transform/Fourier series/transform in solving numerical problems.
4. Demonstrate their written and oral communication skills for this subject.

Module	Details	Hrs.
1.0	<p>Introduction:</p> <p>1.1 Signals and systems: Examples of signals & systems as seen in everyday life, and in various branches of engineering: electrical, mechanical, hydraulic, thermal, and biomedical. Extracting the common essence and requirements of signal and system analysis from these examples.</p> <p>1.2 Continuous time signals: elementary signals, exponential, sine, step, impulse, ramp, rectangular, triangular and operations on signals</p> <p>1.3 Classification of signals: Continuous and discrete time, deterministic and non-deterministic, periodic and aperiodic, symmetric (even) and asymmetric (odd), energy and power, causal and anti-causal signals.</p>	06
2.0	<p>Time domain analysis of Continuous Time Systems</p> <p>2.1 Classification of systems: Static and dynamic, time variant and time invariant, linear and nonlinear, causal and non-causal, stable and unstable systems.</p> <p>2.2 Linear Time Invariant (LTI) systems: Representation of systems using differential equation, Impulse, step and exponential response, system stability, examples on applications of LTI systems, convolution, impulse response of interconnected systems, auto-correlation, cross correlation and properties of correlation</p>	12
3.0	<p>Laplace Transform</p> <p>3.1 Overview of Laplace Transform: Laplace Transform and properties, relation between continuous time Fourier Transform and Laplace Transform, unilateral Laplace Transform.</p> <p>3.2 Analysis of continuous time LTI systems using Laplace Transform: Transfer Function, causality and stability of systems, solution of differential equation using Laplace Transform.</p>	06
4.0	<p>z – Transform</p> <p>4.1 z-Transform of finite and infinite duration sequences, relation between discrete time Fourier Transform and z-Transform, properties, Inverse z-</p>	08

	Transform, one sided z - Transform. 4.2 Analysis of discrete time LTI systems using z-Transform: Transfer Function, causality and stability of systems, frequency response, relation between Laplace Transform and z -Transform.	
5.0	Fourier series of continuous and discrete time signals 5.1 Review of Fourier series: trigonometric and exponential Fourier series representation of signals, magnitude and phase spectra, power spectral density and bandwidth. Gibbs phenomenon. 5.2 Properties of Fourier Series: Linearity, time shifting, time reversal, frequency shifting, time scaling, differentiation, symmetry. Parseval's relation. Examples based on properties, analogy between Continuous Time Fourier Series (CTFS) and Discrete Time Fourier Series (DTFS).	10
6.0	Continuous Time Fourier Transform (CTFT) and Discrete Time Fourier Transform (DTFT) 6.1 Fourier Transform: Fourier Transform and Inverse Fourier Transform on periodic and non-periodic signals, limitations of Fourier Transform and need for Laplace and z -Transform 6.2 Properties of Fourier Transform: Linearity, time shifting, time reversal, frequency shifting, time and frequency scaling, modulation, convolution in time domain, differentiation in time domain, differentiation in frequency domain, symmetry. Parseval's relation. Energy, power spectral density and bandwidth. Definition and problems on DTFT	10
	Total	52

Internal Assessment (IA):

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. The students need to solve total 4 questions.
3. Question No.1 will be compulsory and based on entire syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

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

References:

1. Alan V. Oppenheim, Alan S. Willsky and S. Hamid Nawab, Signals and Systems, PrenticeHall of India, Second Edition, 2002
2. B.P. Lathi, Principles of Linear Systems and Signals, Oxford, Second Edition, 2010.
3. Simon Haykin and Barry Van Veen, Signals and Systems, John Wiley and Sons, Second Edition, 2004.
4. Hwei. P Hsu, Signals and Systems, Tata McGraw Hill, Third edition, 2010.
5. NagoorKani, Signals and Systems, Tata McGraw Hill, Third Edition, 2011.
6. Chi-Tsong Chen, Signals and Systems, Oxford Indian Edition, Third Edition 2012.
7. Luis F. Chaparro, Signals and Systems Using MATLAB, Academic Press, 2011.
8. Michael J Roberts, Fundamentals of Signals and systems, Tata McGraw Hill, special Indian Economy edition, 2009.
9. Rodger E Ziemer, William H. Tranter and D. Ronald Fannin, Signals and Systems, Pearson Education, Fourth Edition 2009.

CLASS: SE (Mechatronics)	Subject Code: MTL407	Semester:-IV
SUBJECT: Applied Electronics Laboratory-II		Credit: 1
Practical to be conducted for batch of students	Practical	02 hours per week

Pre-requisite:

1. MTL308: Applied Electronics Laboratory-I

Objectives:

1. Study of electronic amplifier
2. Study of interfacing
3. Time domain analysis of systems

Outcomes: Learner will be able to...

1. Characterize op-amp
2. do interfacing
3. do time domain characterization of the systems

List of Experiments:

1. Experiment on op amp parameters
2. Experiment on design of application using op amp
3. Experiment on implementation of op amp application e.g. oscillator
4. Experiment on nonlinear application (e.g. comparator or peak detector) of op amp
5. Experiment on ADC and DAC interfacing
6. Experiment on IC 555
7. Experiment on voltage regulator
8. Simulation experiment based on time domain analysis of continuous time systems
9. Simulation experiment on Laplace/z-Transform
10. Simulation experiment on CTFT and DTFT

Term Work:

Term work shall consist of performance of above mentioned 10 experiments with 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.

Term Work Evaluation: 25 Marks (Total marks) = 20 Marks (Experiment) + 05 Marks (Attendance)

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.

CLASS: SE (Mechatronics)	Subject Code: MTL408	Semester:-IV
SUBJECT: Electrical and Electronics Workshop		Credit: 1
Practical to be conducted for batch of students	Practical	02 hours per week

Pre-requisite:

1. MTL308: Applied Electronics Laboratory-I

Objectives:

1. To inculcate skill for electrical engineering works
2. To inculcate skill for electronics engineering works

Outcome: Learner will be able to...

1. demonstrate PCB design and soldering skills
2. demonstrate computer assembly skills
3. demonstrate skills in handling electrical components

Syllabus:

The primary objective is to encourage students to design and implement innovative ideas by development of engineering skills. This will give them in depth practical knowledge from design to the final verification stage. Documentation is important for any activity and students are expected to document their work properly.

Part A:

1. Soldering Techniques and PCB Design
2. Computer hardware
3. Various electrical components (relays, fuses, transformers, motors etc.)
4. Electrical wiring

Part B:

Mini Project: Design and implementation of any real life application preferably based on syllabus of ETC405 (Application of Integrated Circuits). Each student should separately design PCB, solder and test the different circuit.

Term Work:

Four hands on exercises from Part A should be set to have well predefined inference and conclusion.

Few computation/simulation based experiments are encouraged.

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

Term Work Evaluation: 50 Marks (Total marks) = 20 Marks (Part A: Experiment) +20 Marks (Part B: mini project) +10 Marks (Attendance)

Practical and Oral exam will be based on Part A and Part B.

CLASS: SE (Mechatronics)	Subject Code: MTL409	Semester:-IV
SUBJECT: Strength of Materials Laboratory		Credit: 1
Practical to be conducted for batch of students	Practical	Slot of 02 hours per week

Pre-requisites:

1. FEC104 Engineering Mechanics
2. MTC 303 Engineering Materials and Metallurgy

Objectives:

1. To gain knowledge of different types of stresses, strain and deformation induced in the mechanical components due to external loads.
2. To study the distribution of various stresses in the mechanical elements such as beams, shafts etc.
3. To study effect of component dimensions and shape on stresses and deformations.

Outcomes: Learner should be able to

1. Perform tension test.
2. perform hardness test
3. perform torsion test
4. perform impact test
5. perform flexural test

Term Work:

List of Experiment:

1. Tension test on mild steel bar (stress - strain behavior, modulus determination)
2. Test on-tor-steel bar
3. Torsion test on mild steel bar/cast iron bar
4. Brinell hardness test
5. Rockwell hardness test
6. Izod impact test / Charpy test
7. Flexural test on beam (central point load)
8. Flexural test on beam (two point load)

Distribution of marks for Term work shall be as follows:

Laboratory work (experiments/assignments):	20 marks
Attendance (Theory and 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.

Marks distribution: 25 Marks (Total marks) = 15 Marks (Practical) + 10 Marks (Oral)

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	<p>1.1 Manufacturing: Definition, classification of manufacturing processes.</p> <p>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.</p> <p>1.3 Shaping Processes for Plastics: Extrusion, injection molding, blow molding, rotational molding, thermoforming, compression and transfer molding.</p>	07
02	<p>2.1 Hot and Cold Working - Rolling, Forging, Wire Drawing, Extrusion-types- Forward, backward and tube extrusion.</p> <p>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.</p>	08
03	<p>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.</p>	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	<p>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.</p>	12
2	<p>Joints: Cotter Joint, Knuckle Joint, Turn Buckle, Bolted and welded joints for direct and eccentric loading.</p>	09
3	<p>Springs; Design of Helical Springs under static and variable axial loading, Design of Leaf Springs.</p>	07
4	<p>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.</p>	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.Sarna - *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	10
	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.	
5.0	Stability & Compensation Techniques	09
	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	
6.0	Analog and Digital Control	06
	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.	
		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	<p>General Concepts</p> <p>1.1 Basic Concepts: Microprocessor and Microcontroller, Von Neumann and Harvard, Intel 8085 microprocessor architecture (only)</p> <p>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</p>	4
2.0	<p>8051 Microcontroller</p> <p>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</p> <p>2.2 8051 Assembly Language Programming: Instruction set, Addressing mode, Assembler directives and programs</p> <p>2.3 8051 Interfacing: LED, LCD, seven segment display, keyboard, ADC, DAC, Stepper Motor, Relay and Serial Communication</p>	12
3.0	<p>ARM7: A 32-bit Microcontroller</p> <p>3.1 Architecture: Features of ARM Microcontroller, Operating modes, Architecture, Registers, CPSR, Pipeline, Exceptions, interrupt vector table, memory management, ARM7 processor families</p> <p>3.2 ARM7 Programming: Instruction set, Addressing mode and programs</p>	12
4.0	<p>Embedded Software Development</p> <p>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.</p> <p>4.2 Embedded C-programming concepts: Optimizing for Speed/Memory needs, Interrupt service routines, macros, functions, modifiers, data types, device drivers</p>	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 Synchronization 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", Prentice 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 1st order & 2nd order system
3. Frequency response of 1st order & 2nd 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 Existing 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	<p>Numerical Control of Machines</p> <p>1 Introduction-NC Machine, CNC Machines, DNC, Advantages and Disadvantages of CNC Machines, Applications of CNC</p> <p>2 Components of Numerical Control System-Basic Components, Programme of Instructions</p> <p>3 Classification of Numerical Control Machines</p> <p>4 Engineering Analysis of NC Positioning Systems</p>	06
2	<p>CNC Control System</p> <p>CNC motion controller, Linear, circular, parabolic, cubic, helical interpolator, Positioning and contouring control loops, MCU</p> <p>Output Transducers</p> <p>Introduction, positional transducers, optical gratings, encoders, Inductosyns, Magnescales.</p>	07
3	<p>Tooling for CNC machines</p> <p>Introduction, Cutting tools materials, types of cutting tools, tool selection, ISO specifications, clamping systems in tool holders.</p> <p>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.</p>	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 modern 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, transverse, 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

	<p>Combined viscous and coulomb's damping.</p> <p>Forced Single Degree of Freedom Vibratory System</p> <p>Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation (excluding elastic damper).</p>	
5	<p>Vibration Measurement and Control:</p> <p>Vibration Control:</p> <p>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.</p> <p>Vibration Measurement :</p> <p>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.</p>	10
6	<p>Introduction to Conditioning Monitoring and Fault Diagnosis:</p> <p>Vibration severity criteria, Machine maintenance techniques, machine conditioning monitoring techniques, vibration monitoring techniques, instrumentation systems, choice of monitoring parameter.</p> <p>Balancing:</p> <p>Static and dynamic balancing of rotating masses, balancing of single and multi-cylinder engines, balancing of linkages, balancing machines, balancing of discs and rotors.</p>	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 Publications
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
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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, Princes 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 modern 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, fluidsims, 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).

CLASS: BE (Mechatronics)	Subject Code: MTC701	Semester:-VII	
SUBJECT: CAD/CAM/CAE			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-requisites:

1. MTC502: Machine Design
2. MTL306: Computer Aided Machine Drawing Laboratory

Objectives:

1. To introduce new and exciting field of Intelligent CAD/CAM/CAE with particular focus on engineering product design and manufacturing.
2. To develop a holistic view of initial competency in engineering design by modern computational methods.

Outcome: A learner will be able to....

1. Identify proper computer graphics techniques for geometric modelling.
2. Transform, manipulate objects and store and manage data.
3. Prepare part programming applicable to CNC machines.
4. Use rapid prototyping and tooling concepts in any real life applications.
5. Identify the tools for Analysis of a complex engineering component.

Modules	Details	Hrs.
01	Computer Graphics and Techniques for Geometric Modeling Computer Graphics: Two dimensional computer graphics, vector generation, the windowing transformation, Three dimensional Computer graphics, viewing transformation, Homogeneous coordinates, Perspective projection, Hidden line removal & hidden surface removal algorithm, light & shade ray tracing. The parametric representation of geometry, Bezier curves, Cubic Spline curve, B-Spline curve, parametric representation of line, circle, ellipse & parabola. Constructive solid geometry (CSG), Boundary Representation (B-Rep), Wire Frame Modeling, Solid Modeling, Surface Modeling, Parametric Modeling, feature based modeling, Feature recognition, Design by feature.	08
02	Transformation, Manipulation & Data Storage 2D & 3D Transformations (Translation, Rotation, & Scaling & Magnification), Concatenations, Matrix representation, Problems & object oriented programming on Transformations. Object transformation, mirror transformation, Artificial Intelligence in Design & Manufacturing, Representation of Knowledge, and Knowledge base Engineering.	08
03	NC & CNC Technology Tape coding & format, Manual Part Programming, Computer Aided Part Programming, CNC functions & advantages, DNC, adaptive Control, CNC programming concepts, Trends & new developments in NC, Part programmers job, functions of a post processor, NC part programming languages, Elements of a APT language, The Macro Statement in APT, NC	09

	programming with interactive graphics. Constructional details of CNC machines, Feedback devices- Velocity & displacement, Machining Centers and its types, Automated Material Handling & storage Systems like Robots, AGVs and AS/RS etc.	
04	Computer Aided Engineering (CAE) Fundamentals of computer aided engineering, CAE includes mass property calculations, kinematic analysis and animation (movement, visualization, simulation and FEA). Case study based on modeling and analysis of structural, thermal/fluid, and dynamic (vibration analysis) system. Parameter optimization.	08
05	Computer Integrated Manufacturing & Technology Driven Practices Introduction, Evolution, Objectives, CIM Hardware and Software, CIM Benefits, Nature and role of the elements of CIM, Identifying CIM needs, Data base requirements of CIM, Role of CAD/CAM in CIM, Obstacles to Computer Integrated Manufacturing, Concept of the future CIM systems, Socio -techno- economic aspects of CIM.	09
06	Rapid Prototyping and Tooling Introduction to RP, Technology Description, Overview of RP, Benefits and Application. RP Processes: Process overviews, STL file Generation, Classes of RP systems: Stereo-lithography Approach (SLA), SLA with photopolymerization (mathematical modelling of the process), SLA with liquid thermal polymerization, Selective Laser Sintering (SLS), Fused deposition modelling, Laminated object manufacturing, Laser powder forming. Prototype properties: Material properties, colour, dimensional accuracy, stability, surface finish, machinability, environmental resistance, operational properties. RP Applications: Design, Concept Models, Form & fit checking, Functional testing, CAD data verification, Rapid Tooling, Rapid manufacturing, Science & Medicine, RP processes for MEMS, Photolithography, Direct Laser Writer, Bulk Lithography for 3D micro fabrication (Modelling of beam propagation and curing in resin system).	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.

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. "CAD/CAM Computer Aided and Manufacturing" by Mikell P. Groover and Emory W. Zimmers, Jr., *Eastern Economy Edition*
2. "CAD/ CAM , Theory & Practice" by Ibrahim Zeid, R. Sivasubramanian, *Tata McGraw Hill Publications*
3. "Computer Graphics" by Donald Hearn and M. Pauline Baker, *Eastern Economy Edition*
4. "CAD/CAM Principles, Practice and Manufacturing Management" by Chris McMahan, Jimmie Browne, *Pearson Education*
5. "CAD/CAM/CIM" by P. Radhakrishan, S. Subramanyan, V. Raju, *New Age International Publishers*
6. "CAD/CAM Principles and Applications" by P.N. Rao, *Tata McGraw Hill Publications*
7. "Principle of Computer Graphics" by William .M. Neumann and Robert .F. Sproul, *McGraw Hill Book Co. Singapore.*
8. David L. Goetsch, Fundamental of CIM technology ,Delmar publication
9. David Bedworth, Computer Integrated Design and Manufacturing, *McGraw Hill*,
10. "CNC Machines" by B.S. Pabla and M. Adithan, *New Age International Publishers.*
11. "Numerical Control and Computer Aided Manufacturing" , T.K. Kundra, P.N. Rao, N.K. Tiwari, *Tata McGraw Hill*
12. "CNC Technology and Programming", Krar, S., and Gill, A., *McGraw Hill publishers*
13. "Computer Integrated Manufacturing- An Introduction with Case Studies" by Paul G. Ranky, *Prentice Hall International*
14. "Flexible Manufacturing Systems" by H.K. Shivanand, M.M. Benal, V.Koti, *New Age International Publishers*
15. "Automation, Production Systems and Computer Integrated Manufacturing ", Groover M.P., *Prentice-Hall of India Pvt. Ltd*
16. "Mathematical Elements for Computer Graphics", Rogers D F I and Adams J A, McGraw-Hill.
17. "Computer Integrated Manufacturing Hand Book" by Eric Teicholz, Joel N. Orr, McGraw Hill International Editions
18. "Rapid Prototyping" Chee Kai Chua World Scientific Publishing
19. "Rapid Prototyping: Principles and Applications" Rafiq Noorani, Wiley
20. "Rapid Prototyping: Principles and Applications" C.K. Chua, K. F. Leong, C.S. Lim

CLASS: BE (Mechatronics)	Subject Code: MTC702	Semester:-VII	
SUBJECT: Manufacturing Planning 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-requisites:

1. MTC501: Manufacturing Processes
2. MTC601: CNC Technology

Objectives:

1. To provide the students with a comprehensive exposure to Manufacturing Planning & Control (MPC) and its significance in Industries.
2. To acquaint the students with various activities of MPC.
3. To provide an insight into the ongoing & futuristic trends in the control of inventory.
4. To appraise the students with the need and benefits of planning functions related to products and processes.
5. To give the students an exposure to concepts of production scheduling and sequencing.

Outcomes: The learner will be able to...

1. Illustrate manufacturing planning functions and manage manufacturing functions in an organization in an optimum manner.
2. Develop competency in scheduling and sequencing in manufacturing operations and effect affordable manufacturing lead time.
3. Manage and control inventory with cost effectiveness.
4. Get conversant with various documents procedural aspects and preparation of orders for various manufacturing methods.

Modules	Details	Hrs.
01	Manufacturing Planning and control System: 1.1 Manufacturing transformation process, Manufacturing as competitive advantage. Manufacturing system components and types. Types of products. MPC system overview objectives and functions such as planning routing, scheduling, dispatching and follow up. 1.2 Forecasting: Need for forecasting, Types of forecast. Extrapolative methods- Moving average method, Exponential smoothing method, Forecast errors, Linear trend model. Causal methods- Simple regression analysis.	09
02	Planning Function: Capacity planning and aggregate planning. Master production schedule, Shop floor Control.	07
03	Inventory Control: 3.1 Basic concepts of inventory, purpose of holding stock and influence of demand on inventory. 3.2 Ordering procedures, Two Bin system, ordering cycle, economical order quantity and economical lot size, ABC analysis and reorder procedures. 3.3 Recent trends- computer integrated PP systems, JIT system and MRP-I, MRP-II and ERP (only theory).	09

04	Scheduling & Sequencing: 4.1 Inputs for scheduling, loading and scheduling devices, factors influencing scheduling, scheduling techniques, use of Gantt Charts and basic scheduling problems. 4.2 Product sequencing, dispatching: progress report & expectation of manufacturing lead time technique for aligning completion time & due dates. 4.3 Project management: concepts of project planning, monitoring and control, elements of network analysis –PERT & CPM, cost analysis & crashing.	10
05	Advanced concepts in production planning I : Mathematical programming approaches- Linear programming problem, Formulation, Simplex method for maximization and minimization, concept of duality.	09
06	Advanced concepts in production planning II : Assignment model, Transportation model. Simulation: Need for simulation, Monte Carlo technique.	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, each of 20 Marks
2. Only 04 questions need to be solved.
3. Question 01 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Emphasize on numerical problem to reflect the concept learnt in the module 5 and 6.

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

References:

1. Manufacturing Planning & Control Systems by Thomas E. Vollman, William L. Berry and others. Galgotia Publications
2. Production and Operations Management by S. N. Chary - T. M. H. Publishing Company.
3. Modernization of Materials Management by L. C. Jhamb - Everest Publishing House.
4. Operation Research by Hamdy H. Taha, *Pearson/Prentice Hall*
5. Operation Research by Wayne Winston, *Cengage Learning*
6. Operation Research by Shah, Ravi, Hardik Soni, *PHI Learning*
7. Operation Research by Panneerselvam, *PHI Learning*
8. Production Operation Research by Adam Ebert, *PHI Learning*
9. Manufacturing Process Planning and System Engineering by Anand Bewoor, Dreamtech Press.
10. Modern production / Operations management by Elwood S. Buffa & Rakesh K. Sarin, *Wiley*
11. Industrial and Production management by Martand Telsang, *S.Chand*
12. Manufacturing, planning and control Systems by Thomas Vollman, William Berry and others, *Tata Mc-Graw Hill*.
13. Operation Research by J K Sharma, *Macmillan*
14. Production Planning and Inventory Control by S.L.Narasimhan and other. *Prentice Hall*

CLASS: BE (Mechatronics)	Subject Code: MTC703	Semester:-VII	
SUBJECT: Communication 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. MTC305: Applied Electrical and Electronics Engineering
2. MTC406: Signals and Systems

Objectives:

1. To teach fundamental principles of basic communication systems.
2. To teach the various characteristics of different types of antennas.
3. To teach the cellular concepts.

Outcomes: Learner will be able to...

1. Compare and contrast the significance and limitations of analog and digital communication systems.
2. Demonstrate the knowledge of antennas in communication systems
3. Demonstrate a clear understanding of fundamentals of wireless and mobile communication systems and standards.

Module No.	Topics	Hrs.
1.0	Basics of Communication System 1.1 Block diagram, electromagnetic spectrum, signal bandwidth and power, types of communication channels 1.2 Types of noise, signal to noise ratio, noise figure, and noise temperature	06
2.0	Analog Communication 2.1 Amplitude Modulation: Basic concept, signal representation, need for modulation, Spectrum, waveforms, modulation index, bandwidth, voltage distribution, and power calculation. 2.2 DSBFC: Principles, modulating circuits, low level and high level transmitters DSB suppressed carrier:- Multiplier modulator, nonlinear modulator, and switching modulator Single Side Band (SSB):- Principle, Filter method, phase shift method and third Method. 2.3 Amplitude demodulation: Diode detector, practical diode detector, and square law detector.	10
3.0	3.1 Frequency modulation (FM): Basic concept, mathematical analysis, frequency spectrum of FM wave, sensitivity, phase deviation and modulation index, frequency deviation and percent modulated waves, bandwidth requirement of angle modulated waves, deviation ratio, narrow Band FM, and Wide Band FM. 3.2 Transmitter: Direct FM transmitter, indirect FM Transmitter, noise triangle in FM, pre-emphasis and de-emphasis. 3.3 Phase modulation (PM): Principle and working of Transistor direct PM modulator and relationship and comparison between FM and PM.	10

	3.4 FM demodulation: Balance slope detector, Foster-Seely discriminator, ratio detector, Phase lock loop(PLL) FM demodulator, amplitude limiting and thresholding, comparison between FM demodulators, comparison between AM, FM and PM.	
4.0	Digital Communication 4.1 Introduction to digital communication system, significance of AWGN channel, pulse dispersion in the channel. 4.2 Digital Modulation formats, coherent and non-coherent reception. 4.3 Binary Modulation Techniques: BPSK, BFSK and BASK. 4.4 M-ary Modulation techniques: QPSK, M-ary PSK, MSK, M-ary FSK, M-ary QAM, Differential encoded BPSK & D-QPSK.	12
5.0	Antennas and Wave Propagation 5.1 Antenna Parameters: Radiation intensity, directive gain, directivity, power gain, beam width, band width, gain and radiation resistance of current element. 5.2 Half-wave dipole and folded dipole: Reciprocity principle, effective length and effective area, radiation from small loop and its radiation resistance, Helical antenna. 5.3 Types of wave propagation: Ground, space, and surface wave propagation, tilt and surface waves, impact of imperfect earth and earth's behavior at different frequencies.	08
6.0	Wireless Networks and Mobile Communication Systems 6.1 Description of cellular system, Frequency Reuse, Co-channel and Adjacent channel interference, Propagation Models for Wireless Networks, Multipath Effects in Mobile Communication, Models for Multipath Reception. 6.2 Evolution of Modern Mobile Wireless Communication System - First Generation Wireless Networks, Second Generation (2G) Wireless Cellular Networks, Major 2G standards, 2.5G Wireless Networks, Third Generation 3G Wireless Networks, Wireless Local Area Networks (WLANs), Cellular – WLAN Integration.	06
	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 Examination:

1. Question paper will comprise of total six questions, each of 20 Marks
2. Only 04 questions need to be solved.
3. Question 01 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Emphasize on numerical problem to reflect the concept learnt in the module 5 and 6.

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

References:

1. Kennedy and Davis, “*Electronics Communication System*”, Tata McGraw Hill, Fourth edition.
2. Taub Schilling and Saha, “*Principles Of Communication Systems*”, Tata Mc-Graw Hill, Third Ed.
3. R.K. Shevgaonkar, “*Electromagnetic Waves*”, TATA McGraw Hill Companies, 3rd Edition, 2009.
4. Theodore S. Rappaport, “*Wireless Communications*”, Prentice Hall of India, PTR publication
5. Vijay Garg, “*Wireless Communications & Networking (The Morgan Kaufmann Series in Networking)*”, Morgan Kaufmann Publishers, 1st Edition

CLASS: BE (Mechatronics)	Subject Code: MTC704	Semester:-VII	
SUBJECT: Automotive Electronics			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

Prerequisite:

1. FEC102 Applied Physics
2. FEC105 Basic Electricity and Electronics
3. MTC 305 Applied Electrical and Electronics Engineering

Objective:

1. To study working principles of sensors and actuators used in automobiles
2. To study working of microcontroller based systems used in automobile
3. To study working of electric vehicle and electronic transmission

Outcomes: Learner will be able to ..

1. Identify and select sensors and actuators for specific task in automobile
2. Design microcontroller based system for automobile functions
3. Synthesize digital engine control system
4. Analyse electric vehicles

Module	Detailed content	Hrs.
1	Fundamentals of Automotive Electronics 1.1 Current trends in modern automobiles 1.2 Open and closed loop control strategies, PID control, look up tables, 1.3 Introduction to modern control strategies like fuzzy logic and adaptive control. 1.4 Parameters to be controlled in SI and CI engines.	10
2	Sensors and Actuators 2.1 Hall Effect, hot wire, thermistor, piezoelectric and piezoresistive based sensors. 2.2 Introduction, basic sensor arrangement, types of sensors, oxygen concentration sensor, lambda sensor, crankshaft angular position sensor, cam position sensor 2.3 Mass air flow (MAF) rate, Manifold absolute pressure (MAP), Throttle plate angular position, engine oil pressure sensor, vehicle speed sensor, stepper motors, relays, detonation sensor, emission sensors	10
3	Microcontroller Based Systems 3.1 Ideal ADC and DAC converters, quantization noise, performance limitations, different methods of ADC and DAC 3.2 Microprocessors, microcontrollers, types of memory, memory interface, interrupts, input/output interfacing 3.3 Engine control module, powertrain control module, hardware and software components, interfacing with sensors, system integration	10

4	Digital Engine Control System 4.1 Open loop and close loop control system 4.2 Engine cooling and warm up control, idle speed control, acceleration and full load enrichment, deceleration fuel cutoff. 4.3 Fuel control maps, open loop control of fuel injection and closed loop lambda control exhaust emission control, on-board diagnostics, diagnostics 4.4 Future automotive electronic systems, electronic dash board instruments – Onboard diagnosis system	10
5	Electric Vehicles 5.1 Layout of an electric vehicle, traction motor characteristics, tractive effort 5.2 Transmission requirements, vehicle performance, energy consumption, advantage and limitations, specifications, system components, electronic control system	08
6	Transmission Electronics Multiplexing and De-multiplexing electronically controlled automatic transmission system	04
	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 Examination:

1. Question paper will comprise of total six questions, each of 20 Marks
2. Only 04 questions need to be solved.
3. Question 01 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Emphasize on numerical problem to reflect the concept learnt in the module 5 and 6.

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

References:

1. David A. Johns, Ken Martin, “Analog Integrated Circuit Design” John Wiley & Sons, 2002.
2. M. A. Mazadi and J. C. Mazadi, “*The 8051 Microcontroller and Embedded Systems*”, Pearson Education, New Delhi
3. Robert Bosch, “Automotive Hand Book” SAE, 5th edition, 2000.
4. William B.Riddens -Understanding Automotive Electronics, 5th edition- Butter worth Heinemann Woburn- 1998.
5. Crouse W.H. “Automobile Electrical Equipment” McGraw Hill Book Co., Inc., New York 3rd edition, 1986
6. Mehrdad Ehsani, Yimin Gao, sebastien E. Gay and Ali Emadi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRS Press, 2004

CLASS: BE (Mechatronics)	Subject Code: MTL706	Semester:-VII
SUBJECT: CAD / CAM / CAE Laboratory		Credit: 1
Practical to be conducted for batch of students	Practical	Slot of 02 hours per week

Pre-requisites:

1. MTL607: CNC Technology Laboratory
2. MTL306: Computer Aided Machine Drawing Laboratory
3. MTC502: Machine Design

Objectives:

1. To introduce new and exciting field of Intelligent CAD/CAM/CAE with particular focus on engineering product design and manufacturing.
2. To develop a holistic view of initial competency in engineering design by modern computational methods.

Outcome: A learner will be able to....

1. Identify proper computer graphics techniques for geometric modelling.
2. Transform, manipulate objects and store and manage data.
3. Prepare part programming applicable to CNC machines.
4. Use rapid prototyping and tooling concepts in any real life applications.
5. Identify the tools for Analysis of a complex engineering component.

List of Exercises:

1. Programming for transformations,
2. Solid modeling using any 3D modeling software
3. Part programming and part fabrication on CNC trainer (Turning / Milling)
4. Geometrical optimization of any mechanical component using computer aided engineering concepts.
5. Development of physical 3D mechanical structure using any one of the rapid prototyping processes.
6. Rapid tooling for any one of the engineering or medical applications.

Term Work:

Term work shall consist of all exercises from the above list and a course project in a group of not more than three (3) students on either computer aided engineering or rapid prototyping and tooling.

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

- | | |
|---------------------------|------------|
| 1. Exercises | : 15 Marks |
| 2. Course Project | : 05 Marks |
| 3. Attendance (Practical) | : 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 / Oral Examination:

Practical examination of 2 hours duration based on any one of the following.

- 1) Programming for Algorithms, transformations.
- 2) Part designing and fabrication on 3D printer.
- 3) 3D modeling on software.
- 4) Analysis of component for optimization

The distribution of marks for oral-practical examination shall be as

follows: Practical Examination 15
marks

Oral 10 Marks

1. Evaluation of practical/oral examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.

CLASS: BE (Mechatronics)	Subject Code: MTL707	Semester:-VII
SUBJECT: Communication 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

Objectives:

1. To teach fundamental principles of basic communication systems.
2. To teach the various characteristics of different types of antennas.
3. To teach the cellular concepts.

Outcomes: Learner will be able to ..

1. Compare and contrast the significance and limitations of analog and digital communication systems.
2. Demonstrate the knowledge of antennas in communication systems
3. Demonstrate a clear understanding of fundamentals of wireless and mobile communication systems and standards.

List of Experiments:

1. Experiment on amplitude modulation
2. Experiment on amplitude demodulation
3. Experiment on frequency modulation
4. Experiment on FM demodulation
5. Experiment on digital communication
6. Experiment on digital communication
7. Experiment on antennas
8. Experiment on antennas
9. Experiment on wireless networks
10. Experiment on mobile communication

Term Work:

Term work shall consist of all exercises from the above list.

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

1. Exercises : 20 Marks
2. Attendance (Practical) : 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 / Oral Examination:

Practical exam will be based on the performance of one of the experiments mentioned in the list.

The distribution of marks for oral-practical examination shall be as follows: Practical Examination 15 marks

Oral 10 Marks

1. Evaluation of practical/oral examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.

CLASS: BE (Mechatronics)	Subject Code: MTE7051	Semester:-VII	
SUBJECT: Digital Signal Processing			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. MTC406: Signals and Systems

Objectives:

1. To introduce transform domain analysis of LSI systems, discrete Fourier transform and its computation
2. To teach design of FIR and IIR digital filters
3. To teach finite-word length effect, architecture of DSP processor and cover some applications of DSP

Outcomes: Learner will be able to ...

1. Analyze LSI systems in z -transform domain.
2. Apply algorithms for efficient computation of DFT in solving numerical problems.
3. Design FIR and IIR digital filters based on given specifications.
4. Analyze effect of finite word length on digital signal processing.
5. Explain basic architecture of DSP processors & some of the applications of DSP.
6. Demonstrate spoken, written and presentation skills in the subject of DSP.

Module	Topics	Hrs.
1.0	Transform Analysis of Linear Shift Invariant (LSI) System 1.1 Review of z -transform and its properties, response to sinusoidal and complex exponential signals, steady-state response to periodic input signals, response to aperiodic input signals, relationships between the system function and the frequency response function, computation of the frequency response function. 1.2 LSI systems as frequency-selective filters like; low pass, high pass, band pass, notch, comb, all-Pass filters, and digital resonators. 1.3 Invertibility of LSI systems, minimum-phase, maximum-phase, mixed-phase systems.	12
2.0	The Discrete Fourier Transform and Efficient Computation. 2.1 Frequency domain sampling and reconstruction of discrete time signals, discrete Fourier transform (DFT), DFT as a linear transformation, properties of the DFT, relationship of the DFT to other transforms. 2.2 Fast Fourier Transform: Radix-2 and split-radix fast Fourier transform (FFT) algorithms and their applications	12
3.0	Design of Digital filters and Implementation 3.1 Design of Infinite Impulse Response (IIR) filters using impulse invariant method and bilinear transformation method, Butterworth and Chebyshev filter approximation. 3.2 Concepts of Finite Impulse Response (FIR) filter, symmetric and anti-symmetric FIR filter, FIR filter design using window method and frequency sampling method. 3.3 Realization structures for IIR and FIR filters using direct form structures, cascade, parallel structures, and lattice, ladder structure (only conceptual understanding)	12

4.0	Analysis of Finite Word length effects: Representation of Numbers in Digital System - Fixed and Floating point Numbers, Finite word length effects, Errors due to quantization, rounding and truncation, Limit cycle oscillation.	06
5.0	Introduction to Digital Signal Processors 5.1 Introduction to TMS320C54 Processor architecture 5.2 Features of digital signal processor, Central processing unit, MAC Unit, CSSU, Memory, Addressing modes, Pipelining.	05
6.0	Applications of Digital Signal processing: 6.1 Dual –Tone multi frequency signal detection, spectral analysis of sinusoidal signals, spectral analysis of non-stationary signals, and spectral analysis of random signals. 6.2 Application to Digital Communications: Pulse Code Modulation, Time-Division Multiplexing, Spread Spectrum & Orthogonal Frequency-Division Multiplexing.	05
		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 total six questions, each of 20 Marks
2. Only 04 questions need to be solved.
3. Question 01 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

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

References:

1. Alan V. Oppenheim and Ronald Schafer, “*Discrete Time Signal Processing*”, Pearson Education
2. J. Proakis, D. G. Manolakis, and D. Sharma, “*Digital Signal Processing: Principles, Algorithms and Applications*”, Pearson Education.
3. Robert Schilling and Sandra Harris, “*Fundamentals of Digital Signal Processing using MATLAB*”, Cengage Learning.
4. Sanjit K.Mitra, “*Digital Signal Processing*”, McGrawHill education
5. Luis F. Chaparro, “*Signals & Systems using Matlab*”, Academic Press, 2011.

CLASS: BE (Mechatronics)	Subject Code:MTEL7051	Semester:-VII
SUBJECT: Digital Signal Processing Laboratory		Credit-1
Practical to be conducted for batch of students	Practical	Slot of 02 hours per week

Pre-requisite:

1. MTC406: Signals and Systems

Objectives:

1. To simulate & analyze basic signals & systems for enhanced understanding of concepts studied during theory class for MTE7051 subject.
2. To implement basic algorithms for signal processing on a DSP processor based kit.

Outcomes: Learner will be able to ...

1. Demonstrate programming skills for enhanced understanding of digital signal processing concepts (e.g., convolution, correlation, DFT, FIR & IIR filters, etc.) by analyzing digital signals & systems in time & frequency domain.
2. Demonstrate application of DSP theory in practice by implementing a few real-time signal processing algorithms, such as filtering for noise reduction, generation of PWM signal, etc.

Teacher can conduct any ten experiments based on the syllabus of MTE7051 (Digital Signal Processing). At least two experiments should be conducted on the DSP processors.

Suggested list of experiments:

1. Generation of various basic digital signals and analyzing them in time & frequency domain.
2. Understanding concept of convolution by passing sum of sinusoidal through a digital low-pass filter.
3. Understanding concept of auto- and cross-correlation.
4. Simulating & analyzing notch/comb/all-pass/digital resonator filters in time & frequency domain.
5. Concept of minimum phase system.
6. Concept of frequency resolution & zero-padding.
7. Analyzing various types of windows with respect to transition width & stop band attenuation.
8. Design of basic FIR filter based on windowing.
9. Design of basic FIR filter based on frequency domain sampling method.
10. Design of basic IIR filter.
11. Implementing linear filter using circular convolution.
12. Implementation of radix-2 FFT algorithm & demonstrating use of DFT properties.
13. Analyzing finite word length effect on a digital filter.
14. Generation of PWM waveform using a DSP processor.
15. Computation of DFT using DSP processor.
16. Implementation of a filter using DSP processor.
17. Real-time filtering of speech signal using DSP processor.

Term Work:

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

- | | |
|---------------------------|------------|
| 1. Exercises | : 20 Marks |
| 2. Attendance (Practical) | : 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 / Oral Examination:

Practical exam will be based on the performance of one of the experiments mentioned in the list.

The distribution of marks for oral-practical examination shall be as follows: Practical Examination 15 marks

Oral 10 Marks

1. Evaluation of practical/oral examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.

CLASS: BE (Mechatronics)	Subject Code: MTE7052	Semester:-VII	
SUBJECT: Neural Network and Fuzzy Logic			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-requisites:

1. FEC101 : Applied Mathematics-I
2. FEC201 :Applied Mathematics-II
3. FEC205 :Structured Programming Approach

Objectives:

1. To conceptualize the working of human brain using Artificial Neural Network.
2. To become familiar with neural networks that can learn from available examples and generalize to form appropriate rules for inference systems.
3. To introduce the ideas of fuzzy sets, fuzzy logic and use of heuristics based on human experience.

Outcomes: Learner will be able to ...

1. Analyze and appreciate the applications which can use Neural Network and fuzzy logic.
2. Identify and describe NNFL techniques and their roles in building intelligent machines.
3. Design inference systems for decision making in manufacturing industries.
4. Realize the difference between learning and programming and explore practical applications of Neural networks (NN).
5. Demonstrate the use of Neuro-fuzzy network for various industry applications.

Module	Detailed Contents	Hours
1	Introduction: Soft computing techniques. 1.1 Basics of Neural Networks: Introduction to Neural Networks, Biological Neural Networks, McCulloch Pitt model. 1.2 Supervised Learning algorithms: Perceptron (Single Layer, Multi layer), Linear separability, Delta learning rule, Back Propagation algorithm. 1.3 Un-Supervised Learning algorithms: Hebbian Learning, Winner take all, Self-Organizing Maps, Learning Vector Quantization.	10
2	Fuzzy Logic: Introduction to fuzzy logic: 2.1 Classical Sets (Crisp sets) : Crisp Sets and Fuzzy Sets, Operations on crisp sets, Properties of crisp sets. 2.2 Fuzzy Sets: Membership functions, Basic Fuzzy set operations, Properties of Fuzzy sets.	08
3	Fuzzy Relations: 3.1 Crisp Relations: Cartesian product, operations on Relations. 3.2 Fuzzy Relations: Fuzzy Cartesian product, Operations on Fuzzy Relations.	07
4	Fuzzy System: Fuzzy Logic and application: Fuzzy qualifiers, Fuzzy inference, Fuzzy Inference System(FIS),Types of FIS, Fuzzification ,defuzzification methods, design of fuzzy controllers.	08

5	Hybrid system: Introduction to genetic algorithm 5.1 Integration of Neural networks, Fuzzy logic and genetic algorithms: Introduction to Adaptive Neuro Fuzzy Inference System(ANFIS) and its application for electromechanical industries. 5.2 Fuzzy back propagation(Fuzzy BP) Network: Fuzzy Neuron, Fuzzy BP Architecture, Learning in Fuzzy BP.	09
6	Case Studies using Neural network and Fuzzy Logic: Expert System design for sensor and actuator selection, Fuzzy Controller design for Metro Train, Washing Machine, Refrigerator, Air Conditioners., Applications of fuzzy logic in pattern recognition and Image processing for electromechanical industries, Model for computing Automobile Fuel Efficiency , Model for color recipes prediction.	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 Examination:

1. Question paper will comprise of total six questions, each of 20 Marks
2. Only 04 questions need to be solved.
3. Question 01 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

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

References:

1. Timothy J.Ross "Fuzzy Logic With Engineering Applications" Wiley.
2. S.N.Sivanandam, S.N.Deepa "Principles of Soft Computing" Second Edition, Wiley Publication.
3. S.Rajasekaran and G.A.Vijayalakshmi Pai "Neural Networks, Fuzzy Logic and Genetic Algorithms" PHI Learning.
4. J.-S.R.Jang "Neuro-Fuzzy and Soft Computing" PHI 2003.
5. Satish Kumar "Neural Networks A Classroom Approach" Tata McGrawHill.
6. Zimmermann H.S "Fuzzy Set Theory and its Applications"Kluwer Academic Publishers.
7. Hagan, Demuth, Beale,"Neural Network Design" CENGAGE Learning, India Edition.

CLASS: BE (Mechatronics)	Subject Code:MTEL7052	Semester:-VII
SUBJECT: Neural Network and Fuzzy Logic Laboratory		Credit-1
Practical to be conducted for batch of students	Practical	Slot of 02 hours per week

Pre-requisites:

1. FEC101 : Applied Mathematics-I
2. FEC201 :Applied Mathematics-II
3. FEC205 :Structured Programming Approach

Objectives:

1. To conceptualize the working of human brain using Artificial Neural Network.
2. To become familiar with neural networks that can learn from available examples and generalize to form appropriate rules for inference systems.
3. To introduce the ideas of fuzzy sets, fuzzy logic and use of heuristics based on human experience.

Outcomes: Learner will be able to...

1. To analyze and appreciate the applications which can use Neural Network and fuzzy logic.
2. To identify and describe NNFL techniques and their roles in building intelligent machines.
3. To design inference systems for decision making in manufacturing industries.
4. To realize the difference between learning and programming and explore practical applications of Neural networks (NN).
5. To demonstrate the use of Neuro-fuzzy network for various industry applications.

List of Experiments:

All the programs should be implemented in C/C++/Java/MATLAB under Windows or Linux or Ubuntu environment. Experiments can also be conducted using available open source tools like OCTAVE and SCILAB.

1. One case study on Fuzzy/Neural/GA based papers published in IEEE/ACM/Springer or any prominent journal.
2. To implement activation function and problems on linear separability
3. To implement Fuzzy sets and Relations.
4. To implement Fuzzy Controllers.(Application to be designed for electromechanical industry)
5. To implement Basic Neural Network learning rules.
6. To implement any Supervised Learning algorithm.
7. To implement any Unsupervised Learning algorithm.
8. To implement a simple application using ANFIS.(Eg. Color recipes prediction, Automobile Fuel Efficiency Prediction)

Any other practical's covering the syllabus topics and subtopics can be conducted.

Term Work:

Term work shall consist of all exercises from the above list.

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

- | | |
|---------------------------|------------|
| 1. Exercises | : 20 Marks |
| 2. Attendance (Practical) | : 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 / Oral Examination:

Practical exam will be based on the performance of one of the experiments mentioned in the list.

The distribution of marks for oral-practical examination shall be as follows:

Practical Examination	marks	.....	15
Oral	.....	10	Marks

1. Evaluation of practical/oral examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.

CLASS: BE (Mechatronics)	Subject Code: MTE7053	Semester:-VII	
SUBJECT: Micro-Electro Mechanical 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-requisites:

1. MTC303: Engineering Materials and Metallurgy
2. MTC501: Manufacturing Processes

Objectives:

1. To gain an understanding of MEMS and its applications
2. To know the understanding of the fundamental principles behind the operation of MEMS
3. To understand the unique fabrication processes used in development of MEMS
4. To understand the technique used for characterization of MEMS.

Outcome: Learner will be able to...

1. Design fabrication process plan for development of MEMS
2. Identify characterization and assembly techniques for developed MEMS.
3. Develop physics based model of MEMS.

Modules.	Details	Hrs.
01	Introduction to MEMS & Applications <ul style="list-style-type: none"> • Introduction to Micro-Electro-Mechanical Systems, • Applications and materials for MEMS, • Advantages & disadvantages of micro-sensors, and micro-actuators. 	6
02	Sensors and Actuators in Micro-domain <ul style="list-style-type: none"> • Concept of sensors & actuators, • Sensing & Actuation principles: Mechanical Sensing, Capacitive, Electrostatic, Electromagnetic, Piezo Resistive, Piezo Electric, Thin Films, Shape Memory Alloys • Comb Drive Actuation & Sensing. Micro-mechanisms, Air-Bag Sensors, Chemical Sensors • Sensors & Actuators for Automotive, Biomedical, Industrial applications 	8
03	Fabrication Methods Microfabrication Methods (VLSI Techniques) <ul style="list-style-type: none"> • Positive and Negative Photoresists, • Bulk Micromachining, • Surface Micromachining, • Etching (Isotropic and Anisotropic), • Deposition techniques such as CVD (Chemical Vapor Deposition), Metallization Techniques. 3D High Aspect Ratio Techniques <ul style="list-style-type: none"> • LIGA, • Microstereolithography, • IH-Process, • Ion-beam Lithography Bulk Lithography (layer-less 3D microfabrication)	12

04	<p>Modelling and Simulation Techniques</p> <ul style="list-style-type: none"> • Scaling Laws, Governing Equations • Modelling of Mechanical Structures via classical methods, Newtons Laws, Thermal Laws, Fluid Flow Analysis • Micro-mechanism modelling and analysis techniques : Lumped Parameter Modelling and Distributed Parameter Modeling • Modelling of Micro-channel as heat exchanger, accelerometers • Numerical Methods used for analysis of MEMS. 	8
05	<p>Characterization Techniques</p> <p>Topography Methods (Optical, Electrical and Mechanical Methods)</p> <ul style="list-style-type: none"> • Microscopy, STM (Scanning Tunneling Microscopes), • SEM (Scanning Electron Microscopes), AFM (Atomic Force Microscopes) <p>Mechanical Structure Analysis</p> <ul style="list-style-type: none"> • Deformation & Vibration Measurement Techniques (Piezo resistive and piezo electric) <p>Interferometry Techniques,</p> <ul style="list-style-type: none"> • ESPI (Electronic Speckle Pattern Interferometry), • Laser Techniques, Laser Doppler Vibro-meters, <p>Fluid, Thermal and Chemical Techniques</p> <ul style="list-style-type: none"> • Fluid Flow Pattern Analysis, Electro-chemical Analysis, • PIV Techniques • Spectroscopy 	10
06	<p>Introduction to Nanotechnology</p> <ul style="list-style-type: none"> • CNT (Carbon Nano Tubes) Applications, its properties, and Fabrication Method, • Nano-mechanical Systems (NEMS), • Nano-tribology, & nano-indentation techniques, • Domestic and Industrial Applications of nanotechnology. 	8

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 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum contents of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

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

References:

1. Julian W. Garden, Vijay K. Varadan and Osama O. Awadelkarim “Microsensors MEMS and Smart devices”, John Wiley and sons, Ltd.
2. Nadim Mulaf and Kirt Williams, “An Introduction to Microelectromechanical systems Engineering”, Artech House.
3. Nicolae Lobontiu and Ephrahim Garcia, “Mechanics of Microelectromechanical systems”, Kluwer Academic Publication.
4. Stanley Wolf and Richard Tauber, “Silicon Processing for the VLSI era Volume -1 Technology”, Lattice press.
5. Vijay K. Varadan, K.J.Vinoy and S. Gopalkrishnan, “Smart Material Systems and MEMS: Design and Development Methodologies”, John Wiley and sons Ltd.
6. Bhushan, “Springer Handbook of Nanotechnology”, Springer Inc.

CLASS: BE (Mechatronics)	Subject Code:MTEL7053	Semester:-VII
SUBJECT: Micro-Electro Mechanical Systems Laboratory		Credit-1
Practical to be conducted for batch of students	Practical	Slot of 02 hours per week

Pre-requisites:

1. MTC303: Engineering Materials and Metallurgy
2. MTC501: Manufacturing Processes

Objectives:

1. To know the overview of essentials for MEMS laboratory
2. To provide insight of fabrication and characterization techniques for MEMS

Outcome: Learner will be able to....

1. Design the process plan for fabrication of microstructure for MEMS
2. Identify the characterization technique for the MEMS

Expt. No.	Aim of the Experiment
01	Study of essentials infrastructure, manufacturing, and characterization facility for MEMS laboratory
02	Study of Wafer characterization, Wafer cleaning & Thermal oxidation and Wafer stress measurements
03	Study of LPCVD Nitride deposition, LPCVD Polysilicon deposition, and Doping.
04	Study of thin-film metal deposition techniques.
05	Study of photolithography for fabrication of high aspect ratio polymer microstructures
06	Study of photolithography for fabrication of 3D ceramic and metal microstructures
07	Study of Reactive Ion Etching technique
08	Experiment on fabrication and characterization of polymer microlens array type structure
09	Experiment on fabrication and characterization of polymer microcantilever sensor
10	Experiment on fabrication and characterization of polymer-carbon black microcantilever sensor
11	Experiment on analysis of stiction effect in high aspect ratio arrayed microstructures.

Term Work:

Term work shall consist of all exercises from the above list.

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

1. Exercises : 20 Marks
2. Attendance (Practical) : 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 / Oral Examination:

Practical examination of 2 hours duration based on any one of the performance (fabrication) based experiments mentioned in the list above. The distribution of marks for oral-practical examination shall be as follows:

Practical Examination	.....	15 marks
Oral	.....	10 Marks

1. Evaluation of practical/oral examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.

CLASS: BE (Mechatronics)		Subject Code: MTE7054		Semester:-VII	
SUBJECT: Optimization				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-requisites:

1. MTC301: Applied Mathematics-III
2. MTC401: Applied Mathematics-IV

Objectives:

1. To familiarize the students with the use of practice oriented mathematical applications for optimization functions in an organization.
2. To familiarize the students with various tools of optimization, probability, statistics and simulation, as applicable in particular scenarios in industry for better management of various resources.

Outcomes: Learner will be able to.....

1. Illustrate the need to optimally utilize the resources in various types of industries.
2. Apply and analyze mathematical optimization functions to various applications.
3. Demonstrate cost effective strategies in various applications in industry.

Module	Details	Hrs.
01	Linear Programming: Linear Programming Problem Formulation, Graphical solution, Simplex method, Twophase method, Big-M method, Principle of Duality, Dual Simplex, Sensitivity Analysis.	12
02	Transportation problem: Formulation - Optimal solution, Degeneracy. Assignment problem: Formulation - Optimal solution, Traveling Salesman problem. Sequencing: Introduction - Flow Shop sequencing - n jobs through two machines - n jobs through three machines - Job shop sequencing - two jobs through 'm' machines.	08
03	Replacement: Introduction - Replacement of items that deteriorate with time - when money value is not counted and counted - Replacement of items that fail completely, group replacement. Queuing Models: Introduction -Single Channel - Poisson arrivals - Exponential service times - with infinite population and finite population models, Multichannel - Poisson arrivals - Exponential service times with infinite population single channel Poisson arrivals.	08
04	Game Theory: Introduction - Minimax (Maximin) -Criterion and optimal strategy - Solution of games with saddle points – Rectangular games without saddle points - 2 X 2 games - dominance principle - m X2 & 2 X n games, graphical method.	08

05	<p>Inventory Models: Introduction - Single item - Deterministic models - Purchase inventory models with one price break and multiple price breaks - shortages are not allowed - Stochastic models - demand may be discrete variable or continuous variable - Instantaneous production - Instantaneous demand and continuous demand and no set up cost.</p>	08
06.	<p>Dynamic programming: Introduction - Bellman's Principle of optimality - Applications of dynamic programming- capital budgeting problem - shortest path problem – Minimum Spanning Tree.</p> <p>Simulation: Definition - Types of simulation models - phases of simulation - applications of simulation - Inventory and Queuing problems - Advantages and Disadvantages - Simulation Languages.</p>	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 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. *Operations Research: Principle and Practices*, A. Ravindran, D. Phillips, Wiley India.
2. *Operations Research*, S. D. Sharma, KedarNath Ram Nath-Meerut.
3. *Operations Research*, R. Panneerselvam, PHI Publications.
4. *Operations Research*, A. M. Natarajan, P. Balasubramani, A. Tamilarasi, Pearson Education
5. *Operations Research - An introduction*, Hamdy A Taha, Pearson Education.
6. *Operations Research*, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.
7. *Operations Research: Methods and Problems*, Maurice Saseini, ArthurYaspan and Lawrence Friedman.
8. *Introduction to O.R*, Hiller & Libermann (TMH)

CLASS: BE (Mechatronics)	Subject Code: MTEL7054	Semester:-VII
SUBJECT: Optimization Laboratory		Credit: 1
Practical to be conducted for batch of students	Practical	Slot of 02 hours per week

Pre-requisites:

1. MTC301: Applied Mathematics-III
2. MTC401: Applied Mathematics-IV

Objectives:

1. To familiarize the students with the use of practice oriented mathematical applications for optimization functions in an organization.
2. To familiarize the students with various tools of optimization, probability, statistics and simulation, as applicable in particular scenarios in industry for better management of various resources.

Outcomes: Learner will be able to.....

1. Illustrate the need to optimally utilize the resources in various types of industries.
2. Apply and analyze mathematical optimization functions to various applications.
3. Demonstrate cost effective strategies in various applications in industry.

Term Work

Term work shall consist of;

1. Assignments: On topics drawn from syllabus of subject MTE7054 “Optimization” [At least 1 assignment per module].
2. Based on topics from syllabus, minimum 06 problems are to be solved and presented with inferences.
3. Exposure to problem solving using MS Office Excel and software packages such as
4. TORA, WinQSB and LINDO is recommended.

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

- Laboratory work (problem solving: manual/programs and journal): **10** marks
- Assignments: **10** marks
- Attendance (Theory and Practical): **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/oral Examination:

Practical examination of 2 hours duration based on any one of the problem solving technique on software platform. Oral examination will be based on entire syllabus.

CLASS: BE (Mechatronics)	Subject Code: MTE7055	Semester:-VII	
SUBJECT: Finite Element Analysis			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

Prerequisites:

1. MTC301: Applied Mathematics-III
2. MTC401: Applied Mathematics-IV

Objectives:

1. To introduce the concepts of Mathematical Modeling of Engineering Problems.
2. To study the applicability of FEM to a range of Engineering Problems.
3. To acquaint with applications of numerical techniques for solving problems.

Outcomes: Learner will be able to...

1. Solve ordinary and partial differential equations using the Galerkin method.
2. Develop the finite element equations to model engineering problems governed by 2nd order partial differential equations.
3. Apply the basic finite element formulation techniques to solve engineering problems.
4. Use commercial FEA software, to solve problems related to mechanical engineering.

Module	Detailed Contents	Hrs.
01	<p>Introduction</p> <p>1.1 Introductory Concepts: Introduction to FEM, Historical Background, General FEM procedure. Applications of FEM in various fields. Advantages and disadvantages of FEM.</p> <p>1.2 Mathematical Modeling of field problems in Engineering, Governing Equations, Differential Equations in different fields.</p> <p>1.3 Approximate solution of differential equations-- Weighted residual techniques, Least squares, Galerkin methods, Boundary Value problems.</p>	08
02	<p>FEA Procedure</p> <p>2.1 Discrete and continuous models, Weighted Residual Methods – Ritz Technique – Basic concepts of the Finite Element Method.</p> <p>2.2 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.</p> <p>2.3 Minimization of a functional. Principle of minimum total potential. Piecewise Rayleigh-Ritz method. Formulation of “stiffness matrix”; transformation and assembly concepts.</p>	08
03	<p>One-Dimensional Problems</p> <p>3.1 One Dimensional Second Order Equations – Discretization – Element types- Linear and Higher order Elements – Derivation of Shape functions and Stiffness matrices and force vectors.</p> <p>3.2 Assembly of Matrices - solution of problems in one dimensional structural analysis, heat transfer and fluid flow (Stepped and Taper Bars, Fluid Network, Spring-Cart systems)</p> <p>3.3 Analysis of Plane Trusses, Analysis of Beams.</p> <p>3.4 Solution of one Dimensional structural and thermal problems using FE Software, Selection of suitable Element Type, Modeling, Meshing, Boundary Condition, Convergence of solution, Result analysis, Case studies.</p>	10

04	<p>Two Dimensional Finite Element Formulations</p> <p>4.1 Introduction, Three noded triangular element, four noded rectangular element, four noded quadrilateral element, eight noded quadrilateral element.</p> <p>4.2 Natural coordinates and coordinates transformations: serendipity and Lagrange's methods for deriving shape functions for triangular and quadrilateral element</p> <p>4.3 Sub parametric, Isoperimetric, super parametric elements. Compatibility, Patch Test, Convergence criterion, Sources of errors.</p>	10
05	<p>Two Dimensional Vector Variable Problems</p> <p>5.1 Equations of elasticity – Plane stress, plane strain and axisymmetric problems.</p> <p>5.2 Jacobian matrix, stress analysis of CST and four node Quadratic element</p> <p>5.3 Solution of 2-D Problems using FE Software (structural and Thermal), selection of element type, meshing and convergence of solution. (Can be covered during practical hours).</p>	08
06	<p>Finite Element Formulation of Dynamics and Numerical Techniques</p> <p>6.1 Applications to free vibration problems of rod and beam. Lumped and consistent mass matrices.</p> <p>6.2 Solutions Techniques to Dynamic problems, longitudinal vibration frequencies and mode shapes. Fourth Order Beam Equation, Transverse deflections and Natural frequencies of beams.</p> <p>6.3 Finding frequencies of beam using FE Software (Can be covered during practical hours).</p>	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 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. Seshu. P. "Textbook of Finite Element Analysis" Prentice Hall of India, 2003.
2. J.N. Reddy, "Finite Element Method" Tata McGraw Hill, 2003.
3. Chandrupatla and Belegundu, "Introduction to Finite Elements in Engineering" PHI / Pearson Education, 2003.
4. Logan. D.L. "A first course in Finite Element Method", Thomson Asia Pvt. Ltd., 2002.
5. Cook R.D., Malkus. D.S. Plesha, ME., "Concepts and Applications of Finite Element Analysis", John – Wiley Sons 2003.
6. S.S. Rao, "The Finite Element Method in Engineering "Butter worth Heinemann, 2001.
7. M. Asghar Bhatti, " FUNDAMENTAL Finite Element Analysis and Applications with Mathematica and MATLAB Computations", Wiley India Pvt. Ltd.

CLASS: BE (Mechatronics)	Subject Code:MTEL7055	Semester:-VII
SUBJECT: Finite Element Analysis Laboratory		Credit-1
Practical to be conducted for batch of students	Practical	02 hours per week

Pre-requisites:

1. MTC301: Applied Mathematics-III
2. MTC401: Applied Mathematics-IV
3. MTC502: Machine Design
4. MTL706: CAD/CAM/CAE Laboratory

Objectives:

1. To introduce the concepts of use of FEA software.
2. To study the applicability of FEM to a range of Engineering Problems.
3. To acquaint with applications of numerical techniques for solving problems.

Outcomes: Learner will be able to...

1. Use FEA software for solutions of various engineering problems.

List of Assignment:

Students should use the commercial software or programmes from the text-books or self-developed programs, to verify the results obtained by manual calculations. The input data and output results of the problem solved using the computer programs should be included in the Journal. The proposed list is as given below;

- 1 Any two problem using bar element
- 2 Any two problems using truss element
- 3 Any two problems using CST element
- 4 Any one problem using axisymmetric element
- 5 Any one problem of free vibration analysis using bar element
- 6 Any one problem on Steady State Heat conduction.

Course Project:

A group of not more than four (04) students, shall do Finite Element Analysis of any mechanical engineering element/system, which involves element selection, assigning properties, meshing, assigning loads and boundary conditions, analysis and result interpretation.

Term Work:

Term work shall consist of minimum 06 exercises and course project. The distribution of marks for term work shall be as follows:

- | | | |
|---|----|--------|
| <input type="checkbox"/> Laboratory work (experiments/assignments): | 10 | Marks. |
| <input type="checkbox"/> Course project: | 10 | Marks. |
| <input type="checkbox"/> Attendance: (Theory and 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.

Practical/Oral examination:

1. Practical examination duration is 2 hours.
2. Assignment for the examination shall be based on the list of exercises mentioned in the term work.
3. The distribution of marks for practical/oral examination shall be as follows:
 - i. Practical performance: 15 marks
 - ii. Oral: 10 marks
4. Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.
5. Students work along with evaluation report to be preserved till the next examination

Course Code	Course/Subject Name	Credits
MTP706 / MTP807	Project I/ II	3 / 6

Objective:

1. To acquaint with the process of undertaking literature survey/industrial visit and identifying the problem
2. To familiarize the process of solving the problem in a group
3. To acquaint with the process of applying basic engineering fundamental in the domain of practical applications
4. To inculcate the process of research

Outcome: Learner will be able to...

1. Do literature survey/industrial visit and identify the problem
2. Apply basic engineering fundamental in the domain of practical applications
3. Cultivate the habit of working in a team
4. Attempt a problem solution in a right approach
5. Correlate the theoretical and experimental/simulations results and draw the proper inferences
6. Prepare report as per the standard guidelines.

Guidelines for Project:

- Students should do literature survey/visit industry/analyze current trends and identify the problem for Project and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem.
- Students should attempt solution to the problem by experimental/simulation methods.
- The solution to be validated with proper justification and report to be compiled in standard format.

Guidelines for Assessment of Project I

- Project I should be assessed based on following points
 - Quality of problem selected
 - Clarity of Problem definition and Feasibility of problem solution
 - Relevance to the specialization
 - Clarity of objective and scope
 - Breadth and depth of literature survey
- Project I should be assessed through a presentation by the student project group to a panel of Internal examiners appointed by the Head of the Department/Institute of respective programme.

Guidelines for Assessment of Project II

- Project II should be assessed based on following points
 - i. Quality of problem selected
 - ii. Clarity of Problem definition and Feasibility of problem solution
 - iii. Relevance to the specialization / Industrial trends
 - iv. Clarity of objective and scope
 - v. Quality of work attempted
 - vi. Validation of results
 - vii. Quality of Written and Oral Presentation
- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Project II should be assessed through a presentation by the student project group to a panel of Internal and External Examiners approved by the University of Mumbai
- Students should be motivated to publish a paper based on the work in Conferences/students competitions

CLASS: BE (Mechatronics)	Subject Code: MTC801	Semester:-VIII	
SUBJECT: Design of Mechatronics 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-requisites:

1. MTC503: Sensors and Actuators
2. MTC504: Control Systems
3. MTC502: Machine Design
4. MTC505: Embedded Systems

Objectives:

1. To present architecture of the mechatronics system design
2. To study on broad spectrum the characteristics of the mechanical and electrical actuators and their selection for mechatronic systems.
3. Development of process plan and templates for design of mechatronic systems

Outcome: Learner should be able to..

1. Interface sensor and actuator for a mechatronic system.
2. Indigenously design and develop a mechatronic system.

Module	Details	Hrs.
01	Introduction to mechatronics systems. Basic building blocks of mechatronic systems. Mechatronics key elements, Mechatronics in home, office and industry automation, Scope of Mechatronics. Advantages of Mechatronics, pre-requisites for Mechatronics.	05
02	Mechanical Engineering and Machines in Mechatronics: Mechanical translation and rotational systems, Fluid systems, guideways, Mechanism used in mechatronics (High resolution scanning mechanisms, Indexing mechanisms), compliant mechanisms, Assembly techniques, Hydraulic and pneumatic actuators, microactuators. Piezoelectric actuators.	08
03	Electrical systems, Electrical actuators, brushless permanent magnet DC motor, Interfacing of DC motors, stepper motor, interfacing of stepper motors, AC servomotor, Drive selection and its applications. Analog to Digital Conversion, Digital to Analog conversion. Performance characteristics of sensors and transducers. Selection criteria for sensors and actuators, interfacing of sensors and actuators.	09
04	Generalized Mechatronics Design Process: Recognition of the Need, Conceptual Design and Functional Specification, First principle Modular Mathematical Modeling, Sensor and Actuator Selection, Drivers for Actuators, Detailed Modular Mathematical Modeling, Control System Design, Design Optimization, Prototyping Hardware-in-the-loop Simulation, Deployment/Life Cycle, Deployment of Embedded Software, Life Cycle Optimization.	12

	<p>Advance Approaches in Mechatronics: Servo control, Process Control, Supervisory Control, Shop Floor Control, Plant Control.</p> <p>Design of Autonomous Mobile Robot: Introduction, Mechanical Design Alternatives (Gearhead DC Motors, Modified Servo Motors, Skid Steering, Explicit Steering), Design Specifications (Drive Motor Sizing, Steering Motor Sizing, Gear System, Kinematic Analysis, Mechanical Constructions), Electronic Circuits and Interfacing (Sensors, Serial Communication Circuit, Robot Circuitry, Motor Driving Circuitry, Communication Strategy, Interfacing the Servo Steering Motor), Software Development (Serial Communication Algorithm, Data Collection, Motion Algorithm, Map Generation).</p>	
05	<p>Design of cantilever beam vibration control system based on piezo sensors and actuators: Introduction, Modeling of the Cantilever Beam and PZT Actuator (Modeling of the Beam, Modeling of the PZT Actuator, Modeling of the Sensor), Beam Experimental Setup (properties and dimensions of the beam, dimensions and bonding techniques), instrumental setup (Charge amplifier, Voltage amplifier, Data Acquisition), Controller and Software (Development of the PID VI),</p>	09
06	<p>Design of Photopolymerization based CAD compatible stereo 3D Printer: Working principle and process plan of Scanning type and Projection type of 3D printer. Components of scanning and projection type printer. Laser system, Dynamic mask mirror, Optical modulator, scanning mechanisms, Slicing, scan path and image projection strategies. Selection of actuator for scanning mechanism, optical sensors and its selection criteria. Layer preparation system. Interfacing of the sensors and actuators. Data communication schemes for projection and scanning systems. System identification and controller design (PID).</p>	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.

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. *Mechatronics*, Kenji Uchino and Jayne R. Giniewicz, publication: Marcel Dekker, Inc.
2. *Applied Mechatronics*- A. Smaili and F. Mrad, OXFORD university press.
3. *Mechatronics System Design* , Shetty and Kolk CENGAGE Learning, India Edition
4. *Introduction to Mechatronics and Measurement Systems* , Alciatore and Histan Tata McGraw-Hill
5. *Mechatronics*, Necsulescu, Pearson education.
6. *Mechatronics - Electromechanics and Control Mechanics* , Mill Springer-Verlag
7. *Mechatronics - Electronic Control Systems in Mechanical Engineering* , Bolton Pearson education
8. *Mechatronics - Electronics in products and processes* , Bradley, et al. Chapman and Hall
9. *Mechatronics - Mechanical System Interfacing* , Auslander and Kempf, Prentice Hall
10. *Introduction to Mechatronics*, Appu Kuttan K.K., OXFORD Higher Education
11. *The Art of Electronics*, Horowitz and Hill Cambridge, University Press
12. *Electromechanical Design Handbook* , Walsh, McGraw-Hill
13. *Electro-mechanical Engineering - An Integrated Approach* , Fraser and Milne
14. *Handbook of Electromechanical Product Design* , Hurricks Longman, John Wiley, Addison Wesley
15. *Understanding Electro-Mechanical Engineering - An Introduction to Mechatronics* , Kamm IEEE
16. *Modeling and control of Dynamic Systems*, Macia and Thaler, CENGAGE Learning, India Edition
17. *Computer Numerical Control of Machine Tools: Thyer. G.R.*
18. *Automatic Control Engineering: Francis. H. Raven.*
19. *Mechatronics*, Nitaigour Mahalik, Tata McGraw-Hill
20. *Mechatronics*, HMT
21. *System Identification: Theory for the User (2nd Edition)* , Lennart Ljung
22. *Design with Microprocessors for Mechanical Engineers*, Stiffler McGraw-Hill

CLASS: BE (Mechatronics)		Subject Code: MTC802		Semester:-VIII	
SUBJECT: Engineering Management and Economics					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-requisites:

1. MTC501: Manufacturing Processes
2. MTC702: Manufacturing Planning and Control

Objectives:

1. To prepare the students understand and appreciate the basic fundamentals of management concepts, theory and application.
2. To make the students understand the building blocks of various management processes in organizations.
3. To prepare the students to understand the impact of Globalization on business practices.
4. To introduce the students to the concepts of Micro and Macro Economics.
5. To prepare the students, such that they are able to comprehend the need, definition, functions and economic significance of financial institutions and markets.

Outcomes: Learner will be able to...

1. Understand and appreciate the basics of managerial concepts and practices used in day to day practices in organizations.
2. Appreciate the need to prepare oneself for holistic thinking and effectively managing organizations.
3. Correlate various micro and macro-economic variables.
4. Understand Economic policies, their relevance and implications.

Module	Details	Hrs.
01	<p>Introduction to management: Brief history of Indian business scenario and recent changes, Globalization and competition, Need for managerial knowledge and skills.</p> <p>Management: Science, Theory and Practice: Definition of Management, Its nature and purpose, Managing- Science or Art? Contributions of F.W. Taylor and Henry Fayol to management theory, Functions of managers, Management and Society: Social responsibility of managers, Ethics of managing.</p>	08
02	<p>Decision making: Importance and limitations of rational decision making, Rationality in decision making, Evaluation of alternatives, Selecting an alternative- three approaches, Programmed and Non-programmed decisions.</p> <p>Organizing: The nature and purpose of organizing, formal and informal organization. Organization levels and Span of management, Principle of span of management and the factors determining an effective span. The structure and process of organizing, Matrix organization, Strategic business units, Line & staff concepts, Functional authority, Benefits and limitations of staff, Decentralization of authority, Delegation of authority.</p>	11

03	<p>Planning: Types of plans, Steps in planning, The planning process, Objectives- Nature of objectives. Concept in Management By Objectives (MBO), Process of MBO, How to Set Objectives? Benefits and weakness of MBO, MBO in the Indian Context.</p> <p>Staffing: HRM and selection: Definition of Staffing, Systems approach to HRM: Overview of staffing, Situational factors affecting staffing. Selection-matching the person with the job, Systems approach to selection, Position requirements and job design, Skills and personal characteristics needed by managers, Matching qualifications with position requirements, Selection process, techniques and instruments, Performance appraisal and its purpose, Choosing the appraisal criteria.</p> <p>Leading: Human factors in managing, Behavioral models, Motivation: Motivation and motivators. Theory of Maslow's Hierarchy of needs, Motivation-Hygiene approach to motivation, Theory X and Theory Y, Special motivational techniques.</p> <p>Leadership: Definition, Ingredients of leadership, Leadership behavior and styles, Communication: Communication process, Communication in an enterprise, Barriers and breakdowns in communications, Effective communication.</p> <p>Controlling: Basic control process, Critical control points and standards, Control as a feedback system, Feed forward control, Requirements for effective controls, Control techniques: Budget and Non-budgetary control devices.</p>	12
04	<p>Introduction to economics : Definition of Economy, Central problems of an economy: what, how and for whom to produce; concepts of production possibility frontier and opportunity cost. Economics, its scope and importance. Introduction to Micro and Macro economics and their comparison.</p>	07
05	<p>MICRO ECONOMICS : 5.1 Consumer's Behaviour : meaning of utility, marginal utility and law of diminishing marginal utility. 5.2 Conditions of consumer's equilibrium using marginal utility analysis: Concept of ordinal utility, law of demand and relation between law of demand & law of diminishing marginal utility. 5.3 Producer's Behaviour: law of supply, variation in supply, Types of elasticity of supply. Types of Market: perfect competition, pure competition, Monopoly and Multi-plant monopoly.</p>	08
06	<p>MACRO ECONOMICS: 6.1 Concept of National Income : Circular flow of income, Distinction between Gross and Net National Income. Different Methods of Measuring National Income, Definition of Money, Functions of Money, Value of Money and Different concepts of Money. 6.2 Economic Policy: Monetary, Income and Fiscal Policies. 6.3 Functions of Central Bank, Functions of Commercial Banks credit Creation, Credit Control Methods, Theory of Inflation, Concepts of Inflation, Effects of Inflation and Anti-inflationary policies.</p>	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.

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. *Introduction to Managerial Accounting*, Larry M. Walther , Christopher J. Skousen
2. *Managerial and Cost Accounting*, Larry M. Walther , Christopher J. Skousen
3. *Essentials of Microeconomics*, Krister Ahlersten
4. *Essentials of Macroeconomics*, Peter Jochumzen
5. *Central Banking & Monetary Policy: An Introduction*, Dr AP Faure, Rhodes University.
6. *Principles of Management*, Harold Koontz, H. Weihrich, and A.R. Aryasri, Tata McGraw-Hill, New Delhi.
7. *Essential of Management*, Harold Koontz and H. Weihrich, Tata Mc Graw-Hill, New Delhi.
8. *Management of Organizational Behavior*, Hersy, Paul and Kenneth Blanchard, PHI.

CLASS: BE (Mechatronics)	Subject Code: MTC803	Semester:-VIII	
SUBJECT: Modeling and Simulation			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. MTC605 Instrumentation and Controller Design

Objectives:

1. To teach the significance of modeling
2. To highlight the importance of simulation

Outcomes: Learner will be able to..

1. Demonstrate a clear understanding of model for any system
2. Analyze any model for the given system.
3. Realize any system with the help of model and the tool for simulation
4. Demonstrate the simulation skill for any given system

Module	Detailed content	Hrs.
1.0	System Modeling 1.1 Types of model Static and dynamic physical and mathematical model 1.2 Step response method two ,three and four parametric model	06
2.0	Mathematical Model 2.1 Necessity of mathematical modeling, principles of mathematical modeling 2.2 Dimensional analysis, scale	10
3.0	Approximating and validating models 3.1 Taylor's formula, algebraic approximations, Numerical approximations 3.2 Validating models	10
4.0	Analysis and control of the systems 4.1 Solution Techniques for Ordinary Differential Equations, Free Response and Eigenvalues 4.2 State-space Equations: Converting to state space, simulating the models using any simulation	08
5.0	Examples of System Models 5.1 Exponential growth and decay – radioactive decay, capacitor charging-discharging 5.2 Freely vibrating pendulum, spring-mass oscillator	08
6.0	System Simulation 6.1 Techniques of simulations, The Monte-Carlo Method 6.2 Types of system Simulation 6.3 Continuous System Simulation: Analog and Hybrid method 6.4 Probability concepts in simulation	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.

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. Clive L. Dym, "Principles of Mathematical Modeling" Academic Press, Second Edition
2. Dean C. Karnopp, Donald L. Margolis, Ronald C. Rosenberg, "System Dynamics: Modeling, Simulation, and Control of Mechatronic Systems," 5th Edition, Wiley
3. Geoffrey Gordon , " System Simulation" Prentice Hall India
4. Karl J Astrom, Tore Huggland " PID Controllers" 2nd Edition
5. Fundamentals of Process Control Theory, Paul Murrill, ISA

CLASS: BE (Mechatronics)	Subject Code: MTE8041	Semester:-VIII	
SUBJECT: Medical Mechatronics			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. MTC405 Application of Integrated Circuit
2. MTC605 Instrumentation and Controller Design

Objectives:

1. To teach the significance of biomedical signal and the challenges in picking the signal
2. To educate students the different mechanism to measure and monitor different biomedical parameters
3. To identify different types of biomedical units such as pathological, diagnostic, therapeutic and prosthetic devices.
4. To help students in enhancing their knowledge about different imaging techniques
5. Mechanical design of the electrodes, prosthetic devices and the miniature as well as EMI /RFI protected cabinet is a major challenge to be looked into by this course.

Outcomes: Learner will be able to ...

1. Select proper electrodes and electrolyte for different measurement of parameters
2. Explain the principle and working of any biomedical equipment
3. Design suitable orthotic and prosthetic devices and applications
4. Explain the working of different imaging techniques in Biomedical Engineering
5. Demonstrate the significance of safety, telemetry and hospital information system in biomedical Instrumentation

Module	Topics	Hrs.
1	Sources of Bioelectric potential, Electrodes and Transducers 1.1 Understand generation of electrical signal in human cell, Resting and Action potential 1.2 Different types of Electrodes, Electrolytes and their significance, Biosensors 1.3 Classification of Biomedical Instruments	08
2	Biopotential Amplifiers and recorders 2.1 The origin of bio-potential, ECG, ENG, EMG, EEG, MEG, ERG etc. The signal conditioners and amplifiers 2.2 Recording systems for the bio-potential listed above and patient monitoring system, Foetal heart rate monitor	08
3	Measurement and analysis techniques 3.1 Blood flowmeters, Cardiac output measurement, pulmonary function analysers 3.2 Blood gas analysers, oximeters, Blood cell counters, Audiometers	08
4	Therapeutic and Prosthetic Equipments 4.1 Cardiac Pacemakers, Cardiac defibrillators, Hemodialysis machine, Electrosurgical unit, Ventilators, Infant incubator, drug delivery devices, 4.2 Orthotic and Prosthetic devices Definition, Need and Classification, Normal Human Locomotion . Gait Cycle, Biomaterials: Definition, Need and Classification, Biological Testing and Biocompatibility, Upper and Lower limb Prosthetic devices. Upper and Lower limb Orthotic devices, Study of various biomaterials and applications	10

5	Fundamentals of medical imaging 5.1 X-ray computed Tomography, Spiral or Helical C T: Slip Ring Technology, C T Angiography. Clinical use & Biological effects and safety, Magnetic resonance imaging Biological effects and safety. Nuclear medical imaging Biological effects and safety, Infrared imaging, Liquid crystal thermography. Microwave hermography. 5.2 Endoscopy, gastroscope, bronchoscope, cystoscope, colonoscope, Enteroscope Lithotripsy.	10
6	Electrical safety, Telemetry and Hospital Information system 6.1 Macroshocks and microshocks hazards, electrical safety and EMI/RFI interference and its testing 6.2 Biomedical telemetry, wireless and multi patient telemetry 6.3 Hospital Information system: Role of database in HIS. Need of Networking in HIS. Overview of Networking, topologies and its configuration. Structuring medical record to carry out functions like admissions, discharges, treatment history etc. Computerization in pharmacy & billing. Automated clinical laboratory systems & radiology information system.	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.

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. Khandpur R. S., Handbook of Biomedical Instrumentation, Tata McGraw Hill, second edition, 2003
2. Carr and Brown, Introduction to biomedical equipment technology, fourth edition, Pearson press, 2003
3. Sujata V. Bhat, Biomaterials, Narosa Publishing House, 2002.
4. W.R.Hendee & E.R.Ritenour, Medical Imaging Physics (3rd eds), Mosbey Year-Book, Inc., 1992.
5. Lesslie Cromwell, Fred J. Weibell, rich J. Pfeiffer Biomedical Instrumentation and Measurements, 2nd Edition, PHI
6. John G. Webster, Bioinstrumentation John Wiley and sons, 2004
7. Joseph Bronzino (Editor-in-Chief), Handbook of Biomedical Engineering, CRC Press, 1995.
8. L.A.Geddes and L.E.Baker,.Principles of Applied Bio-Medical Instrumentation. John Wiley & Sons 1975.
9. Harold E. Smalley, .Hospital Management Engineering . A guide to the improvement of hospital management system. PHI.

CLASS: BE (Mechatronics)	Subject Code: MTE8042	Semester:-VIII	
SUBJECT: Robotics and Machine Vision			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-requisites:

1. MTC603: Dynamics of Machinery
2. MTC503: Sensors and Actuators
3. MTC504: Control Systems

Objectives:

1. To familiarize the students with the significance of robotic system in agile and automated manufacturing processes.
2. To prepare the students to be conversant with robotic elements/ peripherals, their selection and interface with manufacturing equipment's.
3. To familiarize the students with the basics of robot kinematics.

Outcomes: Learner will be able to..

1. Acquire the skills in understanding robot language and programming.
2. Acquire the skill in robot task planning for problem solving.
3. Develop skills in understanding various sensors, robot peripherals and their use.
4. Develop skills in identifying areas in manufacturing, where robotics can be deployed for enhancing productivity.

Modules	Details	Hrs
1	<p>Introduction: Automation & robotics, Robotic System & Anatomy Classification, Future Prospects</p> <p>Robotic Application in Manufacturing: Material transfer, Machine loading & unloading, Processing operations, Assembly & Inspectors</p> <p>Drives: Control Loops, Basic Control System Concepts & Models, Control System Analysis, Robot Activation & Feedback Components, Position & Velocity Sensors, Actuators ,Power Transmission Systems.</p>	8
2	<p>Robot Kinematics: Coordinate Frames, Rotations, Homogeneous Coordinates, Arm Equation of Planer Robot, Four axis SCARA Robot, TCV, Inverse Kinematics of Planer Robot, Four Axis SCARA Robot.</p>	10
3	<p>Trajectory Planning & Robot Dynamics: Manipulator Path Control- Linear, Quadratic and Cubic Interpolation, Work Space Analysis, Robot Dynamics –Langrangian Dynamics of one and two link robot arm</p>	8
4	<p>Programming For Robots: Methods, Robot programme as a path in space, Motion interpolation, level & task level languages, Robot languages; Programming in suitable languages Characteristics of robot</p>	8

5	Machine Vision: Introduction, Low level & High level vision, Sensing & Digitising, Template Matching, Image processing & analysis, Segmentation, Edge detection, Object description & recognition, Interpretation, Noises in Image, Applications.	10
6	Robot Intelligence & Task Planning: Introduction, State space search, Problem reduction, Use of predictive logic, Means -Ends Analysis, Problem solving, Robot Learning, Robot task planning, Robot Vision Social Issues and Economics of robotics	8

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 Programming & Manipulating an Industrial Manipulator along with Machine Vision

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. I.YoremKoren, "Robotics for Engineers"
2. J. F. Engelberger, "Robotics in Practice"
3. Ulrich Rembolds, ChristialBlume, "Computer Integrated Manufacturing Technology and Systems"
4. Ramamurthy, "Computer Aided Design in Mechanical Engineering"
5. Mark Spong, "Robot Dynamics and Control", Wiley India
6. John Craig, "Robotics"
7. Paul R.P., "Robot Manipulators: Mathematics, Programming and Control"
8. Groover and Simmers, "Industrial Robotics"
9. Ernest Deoblin, "Measurement systems"
10. Beckwith and Lewisbuck, "Mechanical Measurements"
11. K. Ogata, "Modern Control Engineering", PHI
12. Benjamin Kuo, "Automatic Control Systems", Wiley India
13. Richard D. Kliafter et al, "Robotic Engineering -an Integrated Approach", PHI
14. Spyros G. Tzafestas, "Intelligent Robotic Systems"

CLASS: BE (Mechatronics)	Subject Code: MTE8043	Semester:-VIII	
SUBJECT: Microfabrication 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-requisites

1. MTC501: Manufacturing Processes

Objectives:

1. To gain an understanding of standard microfabrication techniques (fundamental principles) and the issues surrounding them.
2. To know the major classes, components, and applications of microfabrication.
3. To understand the essentials and constraints of microfabrication processes.

Outcome: Learner will be able to ..

1. Identify appropriate microfabrication process for development of functional microsystem.
2. Apply knowledge of microfabrication techniques to the design and develop a microsystem.
3. Understand the working principle of different microfabrication processes

Module	Details	Hrs.
01	Introduction to microfabrication processes, Additive and subtractive type microfabrication processes. Advantages and disadvantages of additive and subtractive microfabrication. Applications and scope, Microfabrication process and its CAD compatibility.	08
02	Diffusion, Ion Implantation, Chemical–Mechanical Polishing (CMP). Bonding. Glass Micro processing. Surface Micromachining, dimensional uncertainties, sealing processes in surface micromachining, IC compatibility, poly-Si surface micromachining, hinged polysilicon, thick polysilicon, CVD silicon dioxides.	10
03	Photolithography overview, masks, spinning resist and soft baking, , exposure and post exposure treatment, development, post baking, resist, wafer priming, resist stripping, critical dimensions, line width, overall resolution, resist profile, overview of profile type, lift-off technique, Extreme UV lithography, Pattern Generation, Micro stereo lithography (types: scanning, projection, Integral Hardening, (IH), multi-resist, constraint surface), bulk lithography	10
04	Working Principles of Electro-discharge Machining (EDM), Reverse Micro-EDM, Wire cut EDM, laser micromachining, Electro-chemical machining.	08
05	Dry Etching, Sputtering or Ion Etching, Plasma etching, reaction mechanism, Ion energy vs Pressure relationship in a plasma. Chemical Etching, Energy driven anisotropy, Dopant driven anisotropy, Deep Reactive Ion Etching, Comparing dry and wet etching, combining dry and wet etching.	08

06	LIGA and Micromolding: Synchrotron orbital Radiation (SOR), X-ray masks, resist requirement, exposure, development, metal deposition, molding, demolding, sacrificial layers	08
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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.

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. Sami Franssila, "Introduction to Micro fabrication", Wiley 2nd Edition.
2. Marc J Madou, Fundamentals of Microfabrication, The Science of minituarization, second edition, CRC press.
3. Yi Qin, Micromanufacturing Engineering and Technology, Micro and Nanotechnology series, Elsevier.
4. Nadim Mulaf and Kirt Williams, "An Introduction to Microelectromechanical systems Engineering", Artech House.
5. Stanley Wolf and Richard Tauber, "Silicon Processing for the VLSI era Volume -1 Technology", Lattice press.
6. Vijay K. Varadan, K.J.Vinoy and S. Gopalkrishnan, "Smart Material Systems and MEMS: Design and Development Methodologies", John Wiley and sons Ltd.

CLASS: BE (Mechatronics)	Subject Code: MTE8044	Semester:-VIII	
SUBJECT: Machine Interface 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-requisites:

1. MTL307: Object Oriented Programming Laboratory.

Objectives:

1. To stress the importance of a good interface design.
2. To understand the importance of human psychology in designing good interfaces.
3. To motivate students to apply HMI in industrial application.
4. To bring out the creativity in each student – build innovative applications that are user friendly.
5. To encourage students to indulge into research in Machine Interface Design.

Outcomes: Learner will be able to..

1. Design innovative and user friendly interfaces for industrial application.
2. Criticize existing interface designs, and improve them.
3. Design application for social and technical task with safety concern.

Module	Detailed Contents	Hours
1	1.1 Introduction: Introduction to Human Machine Interface, Hardware, software and operating environment to use HMI in various fields.	10
	1.2 The psychopathology of everyday things – complexity of modern devices; human-centered design; fundamental principles of interaction;	
	1.3 Psychology of everyday actions- how people do things; the seven stages of action and three levels of processing; human error;	
2	2.1 GUI – benefits of a good UI; popularity of graphics; concept of direct manipulation; advantages and disadvantages; characteristics of GUI; characteristics of Web UI; General design principles.	10
	2.2 User Interface Design Process: Steps in UI design	
3	3.1 Graphical screen design: graphical design concepts, components of visible language, graphical design by grids	04
	3.2 Beyond screen design: characteristics of good representations, information visualization, Tufte’s guidelines, visual variables, metaphors, direct manipulation	04
4	4.1 Interaction styles and communication – menus; windows; device based controls, screen based controls, feedback and guidance, icons, colors.	08
	4.2 Societal and Individual Impact of User Interfaces: Future Interfaces, Ten Plagues of the Information Age, Overcoming the Obstacle of Animism	
5	5.1 Design principles and usability heuristics: design principles, principles to support usability, golden rules and heuristics, Human Computer Interaction (HCI) patterns	04
	5.2 HCI design standards: process-oriented standards, product-oriented standards, strengths and limitations of HCI Standards	04

6	Case studies: Designing and evaluating Human-Machine Interface (HMI) for 1. Process control application. 2. Flight control system 3. Robotics Welding 4. Air-conditioning system 5. Smart phones 6. Medical Devices	08
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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.

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. Donald A. Normann, “Design of everyday things”, Basic Books; Reprint edition 2002.
2. Wilbert O. Galitz, “The Essential Guide to User Interface Design”, Wiley publication.
3. Ben Shneiderman and Catherine Plaisant, “Designing the user Interface”, Pearson, Addison Wesley.
4. Alan Cooper, Robert Reimann, David Cronin, “About Face3: Essentials of Interaction design”, Wiley publication.
5. Jeff Johnson, “Designing with the mind in mind”, Morgan Kaufmann Publication.
6. “Human-Machine Interface Design for Process Control Applications”, Jean-Yves Fiset, ISA, 2009
7. Dix A. et al., Human-Computer Interaction. Harlow, England: Prentice Hall, 2004, ISBN-10: 0130461091
8. Yvonne Rogers, Helen Sharp, Jenny Preece, Interaction Design: Beyond Human Computer Interaction, 3rd Edition, Wiley, 2011, ISBN-10: 0470665769
9. Guy A. Boy “The Handbook of Human Machine Interaction”, Ashgate publishing Ltd.

CLASS: BE (Mechatronics)		Subject Code: MTE8045		Semester:-VIII	
SUBJECT: PRODUCT DESIGN & DEVELOPMENT					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-requisites:

1. MTC701: CAD/CAM/CAE.

Objectives:

1. To understand fundamental of product design concepts
2. To understand product design methodologies
3. To understand product design needs and issues in industry

Outcomes: Learner will be able to..

1. Design the products as per the customer/industry requirements
2. Apply product design tools and techniques

Module	Detailed Contents	Hours
1	1.1 Introduction to Product Design: product definition, specifications of product, product life cycle. 1.2 Concurrent engineering & Sequential engineering 1.3 Modern product development process. 1.4 Morphology of design.	08
2	2.1 Conceptual Design: generation, selection & embodiment of concepts. 2.2 Product architecture. 2.3 Industrial design: process, need. 2.4 Design Optimization	08
3	3.1 Design for Manufacturing (DFM) and Design for Assembly (DFA) 3.2 Designs for Maintainability. 3.3 Designs for Environment. 3.4 Design for Robustness: Taguchi Designs & Design of Experiments (DOE).	10
4	4.1 Process selection: Important types of manufacturing process and their classification. 4.2 Process and material selection Methods : AHP and fuzzy approach 4.4 Ergonomics approach	08
5	5.1 Value Engineering / Value Analysis. : definition, methodology-FAST 5.2 Case studies. 5.3 Design and Process Failure Mode Effect Analysis (FMEA) 5.4 Economic analysis: Qualitative & Quantitative.	10
6	6.1 Rapid prototyping: Viz. Stereo lithography. FDM, SLS etc. 6.2 Quality function deployment (QFD) 6.3 Case studies 6.4 Legal and social issues 6.5 Patents and IP acts	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 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. Karl T Ulrich, Steven D Eppinger , “ Product Design & Development.” Tata McGrawhill New Delhi 2003
2. Kevin Otto & Kristin Wood Product Design: “Techniques in Reverse Engineering and new Product Development.” 1 / e 2004, Pearson Education New Delhi
3. L D Miles “Value Engineering.”
4. Hollins B & Pugh S “Successful Product Design.” Butter worths London.
5. A K Chitale & R C Gupta, “Product Design and Manufacturing”, PHI, 2012.

CLASS: BE (Mechatronics)	Subject code:MTL805	Semester:-VIII
SUBJECT: Simulation 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. MTC605 Instrumentation and Controller Design

Objectives:

1. To teach the significance of modeling
2. To highlight the importance of simulation

Outcomes: Learner will be able to..

1. Design a system and process as per needs/specifications.
2. Work in multi-disciplinary task.
3. Use modern Engineering tools to solve engineering problems.

List of Experiments:

It is advisable to use required application software for simulation based experiments. Objective is students should get extensive experience in using the most popular modern simulation tools used worldwide. Use of open source software should be encouraged. This will give them confidence in coupling theory with practice and make them aware of trends in design and simulation of both research and industry. Instructors are requested to use their own ideas to help students excel in use of these simulation tools. Followings are the recommendations:

1. Circuit Design with Circuit simulation tools
2. Tools used in control system and instrumentation like Labview
3. Programming with Embedded tools
4. FPGA/CPLD programming tools
5. Modeling with autocad tools
6. Mathematical modeling tools like Scilab/Matlab
7. Tools for implementation of Real Time Operating System
8. Tools used for communication

Also mini-project based on any of the above tools is expected.

Term Work:

Term work shall consist of exercises done on simulation platforms and mini project.

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

- | | |
|---------------------------|------------|
| 1. Exercises | : 25 Marks |
| 2. Mini Project | : 20 Marks |
| 3. Attendance (Practical) | : 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 / Oral Examination:

Practical exam will be based on the performance on the design task given.

The distribution of marks for oral-practical examination shall be as follows:

Practical Examination.....	15 mark
Oral	10 Marks

1. Evaluation of practical examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.

CLASS: BE (Mechatronics)	Subject code:MTL806	Semester:-VIII
SUBJECT: Mechatronics Laboratory	Credit: 1	
Practical to be conducted for batch of students	Practical	Slot of 02 hours per week

Pre-requisites:

1. MTC503: Sensors and Actuators
2. MTC504: Control Systems
3. MTC502: Machine Design
4. MTC505: Embedded Systems

Objectives:

1. To present architecture of the mechatronics system
2. Method of experimental identification of the control system
3. To study interfacing of the electromechanical devices.

Outcome: Learner will be able to...

1. Identify the suitable sensor and actuator for a control system
2. Indigenously design and develop a mechatronic system

Expt. No.	Aim of the Experiment
01	Experiment based on waveform generation, interfacing and control of motors etc.
02	System identification of any one of the actuator
03	Experimental characterization of any one of the sensor.
04	Experimental Identification by frequency response approach of Mechanical, Electrical, Chemical system
05	Development of transfer function based on experimentally identified data, Stability analysis of predicted transfer function, and PID tuning and implementation on experimental setup.
06	Experimental identification of mechanisms such as flexural based systems etc.
07	Experiment on image based navigation and control of robot.
08	Experiment on control of non-linear systems.
09	Experiment on control of inverted pendulum
10	Experiment on system identification and control of scanning mechanism

Term Work:

Term work shall consist of exercises from the above list.

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

1. Exercises : 45 Marks
2. Attendance (Practical) : 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 / Oral Examination:

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

The distribution of marks for oral-practical examination shall be as follows:

Practical Examination 15 marks
Oral 10 Marks

1. Evaluation of practical examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.