Dr. Babasaheb Ambedkar Technological University
(Established as University of Technology in the State of Maharashtra)
(Under Maharashtra Act No. XXIX of 2014)
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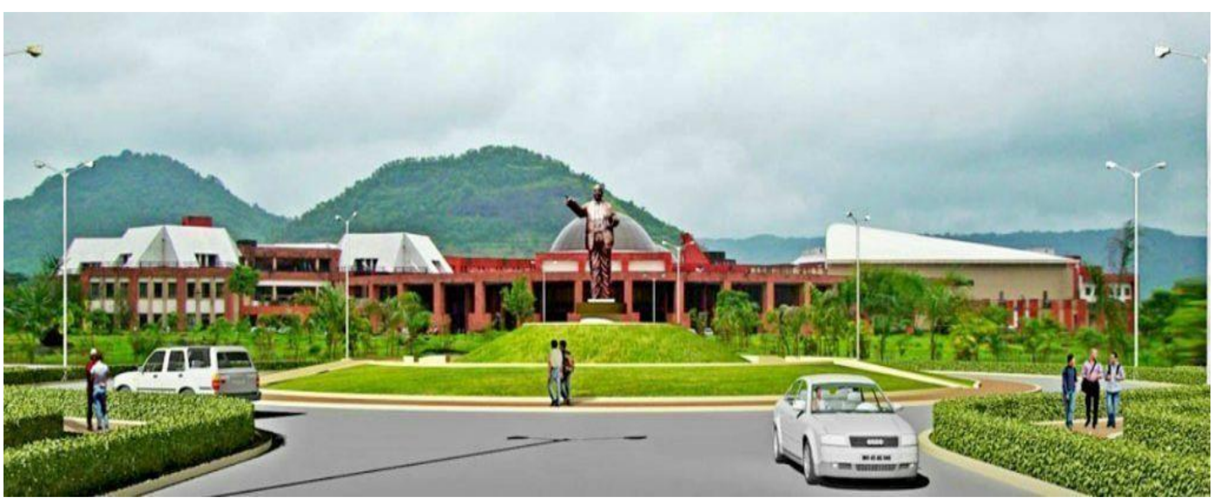
CURRICULUM
UNDER GRADUATE PROGRAMME
B. TECH.

Third Year MECHATRONICS ENGINEERING

ACADEMIC YEAR (AFFILIATED INSTITUTES)
2024-2025



Abbreviations

BSC: *Basic Science Course*

ESC: *Engineering Science Course*

PCC: *Professional Core Course*

PEC: *Professional Elective Course*

OEC: *Open Elective Course*

HSSMC: *Humanities and Social Science including Management Courses*

PROJ: *Project work, seminar and internship in industry or elsewhere*

Course Structure for Semester V
B.Tech in Mechatronics (2024-25)

Semester V											
Course Category	**Course Code**	**Course Title**	**Teaching Scheme**			**Evaluation Scheme**				**No. of Credits**
			L	**T**	**P**	**CA**	**MSE**	**ESE**	**Total**	
PCC 12	BTMXC501	Metrology & measurements	3	1	-	20	20	60	100	4
PCC 13	BTMXC502	Manufacturing Technologies	3	1	-	20	20	60	100	4
PCC 14	BTMXC503	Data Acquisition System	3	1	-	20	20	60	100	4
PEC 2	BTMXPE504 (A/B/C)	Elective-II	3	-	-	20	20	60	100	3
OEC 1	BTMXOE505 (A/B/C/D)	Open Elective-I	3	-	-	20	20	60	100	3
PCC15	BTMXCL506	Metrology & Measurements Lab	-	-	2	60	-	40	100	1
PCC16	BTMXCL507	Manufacturing Technologies Lab			2	60		40	100	1
PROJ-3	BTMXI408	IT – II Evaluation	-	-	-	-	-	100	100	1
Total			**15**	**3**	**4**	**220**	**100**	**480**	**800**	**21**

BSC = Basic Science Course, ESC = Engineering Science Course, PCC = Professional Core Course
PEC = Professional Elective Course, OEC = Open Elective Course, LC = Laboratory Course
HSSMC = Humanities and Social Science including Management Courses

Elective II

Sr. No	Course code	Course Name
1	BTMXPE 504A	Data Processing and Statistics
2	BTMXPE 504B	MEMS/NEMS
3	BTMXPE 504C	Python Programming

Open Elective I

Sr.No.	Course code	Course Name
1	BTMXOE505A	Solar Energy
2	BTMXOE505B	Renewable Energy Source
3	BTMXOE505C	Product Design Engineering
4	BTMXOE505A	Internet of Things and Cloud based Manufacturing

Course Structure for Semester VI
B. Tech in Mechatronics (w.e.f. 2024-25)

Semester VI											
Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme				No. of Credits
			L	T	P	CA	MSE	ESE	Total	
PCC17	BTMXC601	Control System Engineering	3	1	-	20	20	60	100	4
PCC18	BTMXC602	Design of Machine Elements	3	1	-	20	20	60	100	4
PEC3	BTMXPE603 (A/B/C)	Elective-III	3		-	20	20	60	100	3
PEC4	BTMXPE604 (A/B/C/D)	Elective-IV	3		-	20	20	60	100	3
OEC2	BTMOE605 (A/B/C/D/E/F)	Open Elective-II	3		-	20	20	60	100	3
PCC19	BTMXCL606	Computer Aided Design Lab			2	60		40	100	1
PCC20	BTMXCL607	Control System Engineering Lab			2	60		40	100	1
PROJ-4	BTMXS608	B Tech Seminar	-	-	2	60		40	100	1
PROJ-5	BTMXP609	Technical Project for Community Services (TPCS)	-	-	2	60	-	40	100	1
PROJ-6	BTMXI610	Field Training / Industrial Training (minimum of 4 weeks which can be completed partially in fifth semester and sixth semester or in one semester itself).	-	-	-	-	-	-	-	Credits to be evaluated in Sem VII
		Total	**15**	**2**	**08**	**340**	**100**	**460**	**900**	**21**

BSC = Basic Science Course, ESC = Engineering Science Course, PCC = Professional Core Course
PEC = Professional Elective Course, OEC = Open Elective Course, LC = Laboratory Course
HSSMC = Humanities and Social Science including Management Courses

Elective III:

Sr.No	Course code	Course Name
1	BTMXPE603A	Intelligent Systems and Control
2	BTMXPE603B	Adaptive and Predictive control of Mechatronics Systems
3	BTMXPE603C	Virtual Instrumentation

Elective IV:

Sr No	Course code	Course Name
1	BTMXPE604A	Computer Integrated Manufacturing
2	BTMXPE604B	Product Life Cycle Management
3	BTMXPE604C	Finite Element Method
5	BTMXPE604D	Computational Fluid Dynamics

Open Elective II:

Sr.No	Course code	Course Name
1	BTMXOE605A	Quantitative Techniques and Project Management
2	BTMXOE605B	Nanotechnology
3	BTMXOE605C	Energy Conservation and Management
4	BTMXOE605D	Wind Energy
5	BTMXOE605E	Introduction to Probability Theory and Statistics
6	BTMXOE605F	Industrial Engineering

Metrology and Measurements

BTMXC 501	PCC 12	Metrology and Measurements	3-1-0	4 Credits

Teaching Scheme:	Examination Scheme
Lecture: 3 hrs/week Tutorial: 1hr/week	Continuous Assessment: 20 Marks MidSemesterExam:20Marks End Semester Exam: 60 Marks (Duration: 03 hrs)

Pre-Requisites: None
Course Outcomes: At the end of the course, students will be able to:

CO1	Identify techniques to minimize the errors in measurement
CO2	Understand methods and devices for measurement of length, angle, and gear and thread parameters, surface roughness and geometric features of parts.
CO3	Choose limits for plug and ring gauges.
CO4	Explain methods of measurement in modern machineries
CO5	Illustrate the gear metrology and describe working of measuring machines
CO6	Identify various measurement methods for thermo-mechanical properties and geometrical forms

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO1 0	PO11	PO12
CO1				3								2
CO2		2	2		2							
CO3			2	3	2							
CO4						3						
CO5	1					2		3	3		3	2
CO6	1					2		3	3		2	2

Course Contents:

Unit 1: Measurement Standard and Comparators **[10 Hours]**

Measurement Standard, Principles of Engineering Metrology, Line end, wavelength, Traceability of Standards. Types and Sources of error, Alignment, slip gauges and gauge block, Linear and Angular Measurement (Sine bar, Sine center, Autocollimator, Angle Dekker, and Dividing head), Calibration. Comparator: Mechanical, Pneumatic, Optical, Electronic (Inductive), Electrical (LV)

Unit 2: Interferometry and Limits, Fits, Tolerances **[11 Hours]**

Principle, NPL Interferometer, Flatness measuring using slip gauges, Parallelism, Laser Interferometer, Surface Finish Measurement: Surface Texture, Measuring Surface Finish by Stylus probe, Tomlinson and Talysurf. Design of Gauges: Types of Gauges; Limits, Fits, Tolerance; Terminology for limits and Fits. Indian Standard (IS 919-1963), Taylor's Principle.

Unit 3: Metrology of Gears and Measuring Machines **[10 Hours]**

Gear Metrology: Gear error, Gear measurement, Gear Tooth Vernier; Profile Projector Tool marker's microscope. Advancements in Metrology: Universal Measuring Machine, Lasers in Metrology.

Unit 4: Measurement of Thermo-Mechanical Properties **[10 Hours]**

Measurement of temperature, pressure, velocity, Measurement of heat flux,volume/mass flow rate, temperature in flowing fluids, Measurement of thermo- physical properties, radiation properties of surfaces, vibration and noise

Unit 5: Measurement of Geometrical Forms **[11Hours]**

Measurement of geometric forms, straightness, flatness, roundness, etc.Mechanical and optical method soptical projectors,toolmaker"s microscope, and autocollimators, Introduction to CMM, probes for CMM, CMM Software.

Texts:

I. C. Gupta, "Engineering Metrology", Dhanpat and Rai Publications, New Delhi, India.
2 R. K. Jain, "Engineering Metrology", Khanna Publications, 17th edition, 1975.
3.K. L. Narayana, "Engineering Metrology", Scitech Publications, 2nd edition.

References:

1. Ernest O. Doebelin; Measurement Systems: Application and Design; McGraw-Hill, 2004
2. K. J. Hume, "Engineering Metrology", McDonald Publications, 1st edition, 1950.
3. A. W. Judge, "Engineering Precision Measurements", Chapman and Hall, London, 1957.
4. J. F. Galyer, C. R. Shotbolt, "Metrology for Engineers", Little-hamptonBook Services Ltd.,5th edition, 1969.

5. V. A. Kulkarni, A. K. Bewoor, "Metrology & Measurements", TataMcGraw Hill Co. Ltd.,1st edition, 2009.
6. Richard S. Figliola, D. E. Beasley, "Theory and Design for Mechanical Measurements",Wiley India Publication.

Manufacturing Technologies

BTMXC 502	PCC 13	Manufacturing Technologies	3-1-0	4 Credits

Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Identify castings processes, working principles and applications and list various defects in metal casting
CO2	Understand the various metal forming processes, working principles and applications
CO3	Classify the basic joining processes and demonstrate principles of welding, brazing and soldering.
CO4	Understand center lathe and its operations including plain, taper turning, work holdingdevices and cutting tool.
CO5	Understand milling machines and operations, cutters and indexing for gear cutting.
CO6	Know shaping, planning and drilling machines

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1		1	1				1		1
CO2	2	2	1		1	1				1		1
CO3	2	1	1		1	1				1		1
CO4	1		1		1	1				1		1
CO5	2		1		1	1				1		1
CO6	1				1	1				1		1

Course Contents:

Unit 1: Introduction and Casting Processe [08 Hour]
What is manufacturing? Selection of manufacturing processes, Introduction to casting; solidification of metals: Pure metals, Alloys; fluid flow; fluidity of molten metal; heat transfer: Solidification time, Shrinkage, Porosity; Metal casting processes: Sand casting, shell molding, investment casting; Permanent-mold casting, vacuum casting, die casting, centrifugal casting

Unit 2: Metal Forming: Rolling and Forging Processes [08Hours]
Introduction to Rolling; Various Rolling Processes and Rolling Mills. Introduction to forging, Open-die forging; Impression-die and Closed-die forging; various forging Operations; Forging Machines.Extrusion and Drawing Introduction; Extrusion Process; Hot Extrusion; Cold Extrusion: Impact extrusion, Hydrostatic Extrusion; Extrusion Defects; Extrusion Equipment; Drawing Process; Drawing Practice; Drawing Equipment.

Unit 3: Joining Processes [08Hours]
Oxy-fuel-gas Welding; Arc-Welding Processes: Non consumable Electrode; Arc-welding Processes: Consumable Electrode, Shielded Metal-arc Welding, Submerged-arc Welding, Gas Metal-arc Welding. Introduction to solid state welding, Friction Welding, Resistance Welding: Spot, Seam, Projection Welding. Introduction to brazing and soldering.

Unit 4: Machining Processes: Turning and Hole Making [08Hours]
Introduction; The Turning Process; Lathes and Lathe Operations: Lathe Components, Work holding Devices and Accessories, Lathe Operations, Types of Lathes. Boring and Boring Machines; Drilling Machines: Drills, Drill Materials and Sizes, Types of Drilling Machines, Reaming operation and Reamers; Tapping and Taps.

Unit 5: Machining Processes: Milling, Broaching and Gear Manufacturing [07 Hours]
Introduction, Milling and Milling Machines: Peripheral Milling, Face Milling, End Milling, Other Milling Operations and Milling Cutters, Tool holders, Milling Machines; Planning and Shaping: Operations and machines; Broaching and Broaching Machines; Gear Manufacturing by Machining: Form Cutting, Gear Generating by hobbling.

Text:
1. Serope Kalpakjian and Steven R. Schmid, "Manufacturing Engineering and Technology", Addison Wesley Longman (Singapore) Pte. India Ltd., 6th edition, 2009.

References:
1. Milkell P. Groover, " Fundamentals of Modern Manufacturing: Materials, Processes, and Systems", John Wiley and Sons, New Jersey, 4th edition, 2010.

PaulDeGarmo,J.T.**Black, Ronald A.Kohser,"Materials and Processes inManufacturing", Wiley,10thedition,2007.**

Data Acquisition System

BTMXC503	PCC14	Data Acquisition System	3-1-0	4 Credits

Teaching Scheme: Examination Scheme:	**Teaching Scheme: Examination Scheme:**
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to**:**

CO1	Differentiate between single and multichannel Data Acquisition System
CO2	Describe the functional blocks of data acquisition system.
CO3	Operation of different DACs, ADCs and non-linear ADCs.
CO4	Understand data convertor and their applications
CO5	Understand interfacing of ADC and DAC with microprocessor

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes										
	PO1	PO2	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO12
CO1	1	2								2		
CO2			1					2			2	
CO3	1			3		2			2			3
CO4	1		1						2			
CO5	1			3		2			1			3

Course Contents:

Unit I: Introduction **[10Hours]**

Objective of a Data Acquisition System, single channel Data Acquisition System, Multi-channel Data Acquisition System, Components used in Data Acquisition System, Converter characteristics, resolution, Non-linearity, settling time, Monotonicity.

UnitII: Analog to digital converters (ADCS) **[10Hours]**
Classification of A/D converters, Parallel feedback, successive approximation, Ramp comparison, Dual slope integration, voltage to frequency, voltage to time logarithmic type of voltage to time logarithmic types of ADCS.

Unit III: Non-linear data converters (NDC) **[11Hours]**
Basic NDC configurations –Some common NDACS and NADCS –Programmable non-linear ADCS , NADC using optimal sized ROM , High speed hybrid NADC, PLS based NADC, Switched capacitor NDCS. ADC applications: Data Acquisition systems, Digital signal processing systems, PCM voice communication systems, test and measurement instruments, electronic weighing machines.

Unit IV: **Digital to analog converters (DACS)** **[11Hours]**
Principles and design of –Parallel R–2R, weighted resistor, inverted ladder, D/A decoding –Codes other than ordinary binary

Unit V: **Data converter applications** **[10Hours]**
DAC applications, Digitally programmable V/I source, Arbitrary waveform generators, digitally programmable gain amplifiers, Analog multipliers/ dividers, Analog delay lines, interfacing of DACS and ADCS to a microprocessor.

Text Books/References:

Electronic data converters fundamentals and applications –Dinesh K. Anvekar, B.S. Sonde –Tata McGraw Hill.
D/A and A/D converters a user‟s handbook of -E.R. Hnateck, Wiley3.Data converters by G.B.Clayton.
Electronic Analog/ Digital conversions –Hermann Schmid –Tata McGraw Hill.
Electronic instrumentation by HS Kalsi-TMH2n

Elective II

Data Processing and Statistics

BTMXPE504A	PEC 2	Data Processing and Statistics	3-0-0	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 3 hrs/week Tutorial: -	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the classification of data set and representation
CO2	Measure and calculate statistical parameters
CO3	Interpret the results of Regression and Correlation Analysis, for different applications
CO4	Apply the mathematical and probabilistic foundations of statistical inference in computing
CO5	Describe Simple random sampling and tests of significance
CO6	Apply the mathematical and probabilistic foundations to solve engineering problems

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2		1				2			2	
CO2	3	2	1			1		1			2	
CO3	1		1	2		2	1	2		2	1	
CO4	3	2		1		1				1		2
CO5	3	2		2		1				1		2
CO6	3	2		1		2				2		2

Course Contents:

Unit 1: Data and Representation **[07 Hours]**

Introduction to Statistics, Collection of data, classification of data: Primary data, Secondary data, Presentation of data: Diagrammatic and Graphical Representation: Histogram, frequency curve, frequency polygon.

Unit 2: Measures of Central Tendency and Dispersion [08 Hours]
Arithmetic Mean (A.M.) Definition, Mode, Median, Partition Values: Quartiles, Deciles and Percentiles, Box Plot, Percentile ranks. Means of transformed data, Geometric Mean (G.M.)

Definition, Harmonic Mean (H.M.), Weighted Mean : Weighted A.M., G.M. and H.M. Range, Mean deviation Mean square deviation, Variance and Standard Deviation.

Unit 3: Correlation and Regression [08 Hours]
Normal distribution, types, importance, methods of measuring correlation-scatter diagram, Karl Pearson‟s Coefficient of Correlation and Spearman‟s rank Correlation. Regression lines, Difference between regression and correlation, uses of Regression.

Unit 4: Sampling theory and tests of significance [08 Hours]
Methods of sampling: Simple random sampling with and without replacement (SRSWR and SRWOR) stratified random sampling, systematic sampling. Tests of significance – z, t, chi-square and F tests.

Unit 5: Probability [08 Hours]
Sample space and events, probability measure and probability space, random variable as a measurable function, distribution function of a random variable, discrete and continuous-type random variable, stochastic independence of events and of random variables, expectation and moments of a random variable,

Texts:

1. S. C. Gupta – Fundamentals of Statistics, Himalaya Publishing House.
2. Mood, A. M., Graybill, F. A. And Boes, D.C. : Introduction to the Theory of Statistics, McGraw Hill.

References:

1. Biswas and Srivastava – A textbook, mathematical Statistics, Ist Edition, Narosa Publishing House, New Delhi.
2. Gupta, S.C. and V. K. Kapoor – Mathemathical Statistics, Sultan Chand and sons.Hogg,R.V. and Craig, A.T: Introduction to Mathematical Statistics, McMilla

Elective II

MEMS/NEMS

BTMXPE504 – B	PEC2	MEMS / NEMS	3-0-0	3 Credits

Teaching Scheme:	Teaching Scheme: Examination Scheme:
Lecture: 3 hrs/week Tutorial: -	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to**:**

CO1	Understand the multidisciplinary aspects of MEMS and NEMS and their applications
CO2	Review MEMS technology, micro sensors, micro-actuators, their types and applications.
CO3	Understand the methods of fabrication and modelling methods.
CO4	Appreciate the underlying working principles of MEMS and NEMS
CO5	Design devices and model these devices

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12
CO1	2		2			1						1
CO2	3	1	1		2							2
CO3	2		2	2	3	1					2	
CO4	2	2	3		2		2					
CO5	2		3		2		1					2

Course Contents:

Unit I: **Introduction and Historical Background** **[08 Hours]**

Scaling Effects: Need of Miniaturization, Microsystems versus MEMS,Need of Microfabrication, Smart Materials, Structures and Systems, Integrated Microsystems, Applications of Smart Materials and Microsystems.

Unit II: Micro/Nano Sensors, Actuators and Systems overview: Case studies [08 Hours]
Silicon Capacitive Accelerometer, Piezoresistive Pressure Sensor, Conduct metric Gas Sensor, An Electrostatic Comb Drive, A Magnetic Microrelay, Portable Blood Analyzer, Piezoelectric Inkjet Print Head, Micromirror Array for Video Projection, Smart Materials and Systems.

Unit III: Review of Basic MEMS / NEMS fabrication modules [07 Hours]
Oxidation, Deposition Techniques, Lithography (LIGA), Etching, Silicon as a Material forMicromachining, Specialized Materials for Microsystems, Advanced Processes for Micro fabrication.

Unit IV: Micromachining [08 Hours]
Surface Micromachining, sacrificial layer processes, Stiction; Bulk Micromachining, Isotropic Etching and Anisotropic Etching, Wafer Bonding.

Unit V: Mechanics of solids in MEMS / MEMS [08 Hours]
Stresses, Strain, Hookes"s law, Poisson effect, Linear Thermal Expansion, Bending; Energy methods, Overview of Finite Element Method, Modelling of Coupled Electromechanical Systems.

Text Books/References:

1. G. K. Ananthasuresh, K. J. Vinoy, S. Gopalkrishnan K. N. Bhat, V. K. Aatre, Micro and Smart Systems, Wiley India, 2012.
2. S. E. Lyshevski, Nano-and Micro-Electromechanical systems: Fundamentals of Nano- and Microengineering, Vol. 8. CRC press, 2005.
3. S. D. Senturia, Microsystem Design, Kluwer Academic Publishers, 2001.
4. M.H. Bao, Micromechanical Transducers: Pressure sensors, accelerometers, and Gyroscopes, Elsevier, New York, 2000.
5. G. Kovacs, Micromachined Transducers Sourcebook, McGraw-Hill, Boston, 1998.
6. M. Madou, Fundamentals of Microfabrication, CRC Press, 1997.

Elective II

Python Programming

BTMXPE 504C	PEC2	Python Programming	3-0-0	3 Credits

Teaching Scheme:	**Teaching Scheme: Examination Scheme:**
Lecture: 3 hrs/week Tutorial: -	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to**:**

CO1	Read, write, execute by hand simple Python programs
CO2	Structure simple Python programs for solving problems
CO3	Decompose a Python program into functions
CO4	Represent compound data using Python lists, tuples, dictionaries
CO5	Read and write data from/to files in Python Programs

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12
CO1	2	1	3		3		1					2
CO2	2	2	3		3	1		1		2		3
CO3	2	1	3		3	1		1				3
CO4	1	2	3		3	1		1		2		2
CO5	2	1	3		3		1					2

Contents:

Unit 1: Introduction to python programming **[07 Hours]**

Introduction to the Python Programming Language, Working with Python, Numeric Data Types, String Data Type and Operations, Standard Data Types, Data Type Conversions, Commenting in Python

Unit 2: Variables and operators **[08 Hours]**

Understanding Python Variables, Multiple Variable Declarations, Python Basic Statements, Python Basic Operators, Precedence of Operators, Expressions

Unit 3: Control flow and loops **[08 Hours]**
Conditional Statements, Loops in Python, While Loop, Loop Manipulation

Unit 4: Functions **[08 Hours]**
Defining Your Own Functions, Calling Functions, Passing Parameters and Arguments, Python Function Arguments, Anonymous Functions (Lambda Functions), Fruitful Functions (Function Returning Values), Scope of Variables in a Function, Powerful Lambda Functions in Python

Unit 5: I/O and error handling in python **[08 Hours]**
Introduction to I/O (Input/Output), Writing Data to a File, Reading Data from a File, Additional File Methods, Introduction to Errors and Exceptions, Handling I/O Exceptions, Runtime Errors and Handling Multiple Exceptions.

Text Book(s) :

1. Core Python Programming" by R. Nageswara Rao (Dreamtech)
2. Think Python: How to Think Like a Computer Scientist" (2nd Edition) by Allen B. Downey (Shroff/O,,Reilly Publishers, 2016)
3. Python Programming: A Modern Approach" by Vamsi Kurama (Pearson)
4. Data Structures and Algorithmic Thinking with Python" by Narasimha Karumanchi

Reference Books:

1. "Core Python Programming" by Wesley J. Chun (Pearson)
2. Introduction to Python" by Kenneth A. Lambert (Cengage)
3. "Learning Python" by Mark Lutz (O'Reilly)

Open Elective I

Solar Energy

BTMXOE505A	OEC1	Solar Energy	3-0-0	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 3 hrs/week Tutorial: -	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Describe measurement of direct, diffuse and global solar radiations falling on Horizontal and inclined surfaces.
CO2	Analyze the performance of flat plate collector, air heater and concentrating type Collector.
CO3	Understand test procedures and apply these while testing different types of collectors.
CO4	Study and compare various types of thermal energy storage systems.
CO5	Analyze payback period and annual solar savings due to replacement of conventional Systems.
CO6	Design solar water heating system for a few domestic and commercial applications.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12
CO1												
CO2												
CO3												
CO4												
CO5												

Course Contents

Unit 1: Solar Radiation **[08 Hours]**

Introduction, spectral distribution, solar time, diffuse radiation, Radiation on inclined surfaces, measurement of diffuse, global and direct solar radiation.

Unit 2: Liquid Flat Plate Collectors **[08 Hours]**
Introduction, performance analysis, overall loss coefficient and heat transfer correlations, collect or efficiency factor, collect or heat removal factor, testing procedures.

Unit 3: Solar Air Heaters **[08 Hours]**
Introduction, types of air heater, testing procedure.

Unit 4: Concentrating Collectors **[08 Hours]**
Types of concentrating collectors, performance analysis

Unit 5: Thermal Energy Storage and Economic Analysis **[08 Hours]**
Introduction, sensible heat storage, latent heat storage and thermo chemical storage
Solar Pond: Solar pond concepts, description, performance analysis, operational problems.
Economic Analysis Definitions, annular solar savings, payback period.

Text-books
J. A. Duffie, W. A. Beckman, "Solar Energy Thermal Processes", John Wiley, 1974.
K. Kreith,J. F. Kreider, "Principles of Solar Engineering", Tata McGrawHill Publications, 1978.

References:
H. P. Garg, J. Prakash, "Solar Energy: Fundamentals and Applications", Tata McGraw Hill Publications, 1997.
S. P. Sukhatme, "Solar Energy Principles of Thermal Collection and Storage", Tata McGraw Hill Publications, 1996.

Open Elective I

Renewable Energy Sources

BTMOE505B	OEC1	Renewable Energy Sources	3-0-0	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 3 hrs/week Tutorial: -	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs.)

Pre-Requisites: None
Course Outcomes: At the end of the course, students will be able to:

CO1	Explain the difference between renewable and non-renewable energy
CO2	Describe working of solar collectors
CO3	Explain various applications of solar energy
CO4	Describe working of other renewable energies such as wind, biomass , nuclear

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	3		2	3	3	3	2	2		2
CO2	1	1	3	1	2	3	3	3	2	2		2
CO3	2	1	1				3	2		1		2
CO4	3	3			2	3	3	2				1

Course Contents

Unit 1: Solar Energy **[08 Hours]**
Energy resources, Estimation of energy reserves in India, Current status of energy conversion Spectral distribution, solar geometry, Attenuation of solar radiation in Earth's atmosphere, Measurement of solar radiation, Properties of opaque and transparent surfaces.

Unit 2: Solar Collectors **[08 Hours]**
Flat Plate Solar Collectors: Construction of collector, material, selection criteria for flat plate collectors, testing of collectors, Limitation of flat plate collectors, Introduction to ETC.
Concentrating type collectors: Types of concentrators, advantages, paraboloid, parabolic trough, Heliostat concentrator, Selection of various materials used in concentrating systems, tracking.

Unit 3: Solar Energy Applications **[08 Hours]**
Air/Water heating, Space heating/cooling, solar drying, and solar still, Photo-voltaic conversion.

Unit 4: Wind Energy and Biomass **[08 Hours]**
Introduction to wind energy, Types of wind mills, Wind power availability, and wind power development in India. Evaluation of sites for bio-conversion and Introduction to biomass resources, Location of plants, Biomass conversion process

Unit 5: Other Renewable Energy Sources **[08 Hours]**
Tidal, Geo-thermal, OTEC, hydro-electric, Nuclear energy

Text-books

1. Chetan singh Solanki, "Renewable Energy Technologies" ,Prentice Hall of India, 2008.

References :

1. S. P. Sukhatme, "Solar Energy: Principles of Thermal Collection and Storage", Tata McGraw Hill Publications, New Delhi, 1992.
2. G. D.Rai, "Solar Energy Utilization", Khanna Publisher, Delhi, 1992.

Open Elective I

Product Design Engineering

BTMOE505D	OEC1	Product Design Engineering – I	3-0-0	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 3hr/Week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03 hrs)

Pre-requisites: Knowledge of Basic Sciences, Mathematics and Engineering Drawing

Course Outcomes: At the end of the course, students will be able to

CO1	Understand the need for product design
CO2	Apply various methods of idea generation
CO3	Understand various types of prototypes and testing methods
CO4	Understand the product economics at production scale
CO5	Appreciate the environmental concerns in product lifecycle

Course Contents:

Unit 1: Introduction to Engineering Product Design [07Hours]

Trigger for Product/Process/System, Problem solving approach for Product Design ,Disassembling existing product(s) and understanding relationship of components with each other, identifying materials and their processing for final product, fitting of components,understanding manufacturing as scale of the components, Reverse engineering concept,

Unit 2: Ideation & Conceptualization [07 Hours]

Generation of ideas, funneling of ideas, Short-listing of ideas for product(s) as an individual or group of individuals, Market research for need, competitions, Product architecture, Designing of components, Drawing of parts and synthesis of a product from its component parts, 3-D visualization,

Unit 3: Testing and Evaluation Prototyping: **[07 Hours]**

Design Automation, Prototype testing and evaluation, Working in multidisciplinary teams, Feedback to design processes, Process safety and materials, Health and hazard of process operations.

Unit 4: Manufacturing **[07 Hours]**

Design models and digital tools, Decision models, Prepare documents for manufacturing in standard format, Materials and safety data sheet, Final Product specifications sheet, Detail Engineering Drawings (CAD/CAM programming), Manufacturing for scale, Design/identification of manufacturing processes

Unit 5: Environmental Concerns **[07 Hours]**

Product life-cycle management, Recycling and reuse of products, Disposal of product and waste.Case studies.

Reference:

1. Model Curriculum for "Product Design Engineer – Mechanical", NASSCOM (Ref. ID: SSC/Q4201, Version 1.0, NSQF Level: 7)
2. Eppinger, S., & Ulrich, K.(2015). Product design and development. McGraw-Hill Higher Education.
3. Green, W., & Jordan, P. W. (Eds.).(1999).Human factors in product design: current practice and future trends. CRC Press.
4. Sanders, M. S., & McCormick, E. J. (1993). Human factors in engineering and design. McGRAW-HILL book company.
5. Roozenburg, N. F., & E ekels, J. (1995). Product design: fundamentals and methods (Vol. 2). John Wiley & Sons Inc.
6. Lidwell, W., Holden, K., & Butler, J.(2010). Universal principles of designs, revised and updated: 125 ways to enhance usability, influence perception, increase appeal, make better design decisions, and teach through design. Rockport Pub.

Open Elective I

Internet of Things and Cloud based Manufacturing

BTMXOE505A	OEC 1	Internet of Things and Cloud based Manufacturing	3-0-0	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 3 hrs/week Tutorial: -	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand IOT and Cloud computing
CO2	Interpret machine to machine communication
CO3	Use of information system in Manufacturing
CO4	Describe the demand drive and sustainable resource management
CO5	State Internet of Things Privacy, Security and Governance

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1		1	2						1
CO2	1	2			1	1						
CO3	2	1			2			1				2
CO4	2	2			2			1				2
CO5	3	2	1		1	2						3

Course Contents:

Unit1: IoT and Cloud Computing **[08 Hours]**

Introduction, Physical design of IoT, Logical design of IoT, IoT enabling technologies, Domain specific IoTs, IoT design methodology, logical design, IoT physical devices (such as Raspberry Pi, pcDuino, Beaglebone black, Cubieboard) , Introduction to cloud computing: cloud models, cloud service examples, cloud based services & applications, Cloud service and platform

Unit2: Applied Machine to Machine Communication [08 Hours]
Introduction to M2M, Description of M2M Market, Segments/Applications – Automotive, Smart Telemetry, Surveillance and Security, M2M Industrial Automation, M2M Terminals and module

Unit3: Information Systems in Manufacturing [07Hours]
Manufacturing organizations, management, and the networked enterprises, Globalization challenges and opportunities, Dimensions of Information systems, Approaches to study information s y s t e m , Technical and Behavioral approach, Information TechnologyInfrastructure.

Unit4: Introduction to Smart Manufacturing [08Hours]
Introduction; Demand Driven and Integrated Supply Chains; Dynamically Optimized Manufacturing Enterprises (plant + enterprise operations); Real Time, Sustainable Resource Management (intelligent energy demand management, production energy optimization and reduction of GHG), Online Predictive Modelling, Monitoring and Intelligent Control of Machining/Manufacturing and Logistics/Supply Chain Processes.

Unit5: Internet of Things Privacy, Security and Governance [08Hours]
Introduction, Overview of Governance, Privacy and Security Issues, Security, Privacy and Trust in IoT-Data-Platforms for Smart manufacturing, First Steps Towards a Secure Platform, Data Aggregation for the IoT in Smart manufacturing.

Texts:

1. Bahga and V. Madisetti, Internet of Things, A hands-on approach, Create SpaceIndependent Publishing Platform, 1st edition, 2014, ISBN: 978-0996025515.

References:

1.Bahga and V. Madisetti, Cloud Computing, A hands-on approach, Create SpaceIndependent Publishing Platform, 1st edition, 2013, ISBN: 978-1494435141

2.D. Boswarthick, O. Elloumi, and O. Hersent, M2M communications: A systemsapproach, Wiley, 1st edition, 2012, ISBN: 978-1119994756

3.J. Edward Carryer, et al., Introduction to Mechatronic Design, Prentice Hall, 1st edition,2010, ISBN: 978- 8131788257.

4.K. Laudon and J. Laudon, Management Information Systems, 14th edition, PearsonHigher Education, 2016, ISBN: 9780136093688.

Metrology and Measurements Lab

BTMXCL506	PCC 15	Metrology and Measurements Lab	0-0-2	1 Credits

Teaching Scheme:	**Examination Scheme:**
Practicals: 2 hrs/week	Continuous Assessment: 60 Marks End Semester Exam: 40 Marks

List of Practical's/Experiments (Minimum 08 experiments out of the following):

1. Calibration of pressure gauge using dead weight gauge calibrator.
2. Measurement of displacement using LVDT.
3. Calibration of strain gauge.
4. Measurement of flow rate using orifice, venturi - and Rota- meters andtheir error analysis.
5. Measurement of flow rate using microprocessor based magnetic flow meter, vortex, ultrasonic, turbine flow meters
6. Determination of characteristics of thermocouples, RTD, thermistors
7. To calibrate the given micrometer using slip gauge as standard
8. Measurement of taper by sine bar.
9. To calibrate a dial gauge indicator.
10. Study and use of optical flat.
11. Surface roughness measurement.
12. Measurements using Tool makers‟ microscope
13. To measure the major, minor and effective diameter by using floating carriage diameter measuring machine.
14. Inspection of gear by Gear Rolling Tester

Manufacturing Technologies Lab

BTMXCL507	PCC 16	Manufacturing Technologies Lab	0-0-2	1 Credit

Teaching Scheme:	Examination Scheme:
Practical‟s: 2 hrs/week	Continuous Assessment: 60 Marks End Semester Exam: 40 Marks

List of Practical's/Experiments (Minimum 6 practical's out of the following)

1. Making a job with a process plan involving plain, step and taper turning as well thread cutting operations on a Centre lathe.
2. Preparation of process planning sheet for a job including operations such as milling, drillingand shaping.
3. Making a spur gear using universal dividing head on milling machine.
4. Making a simple component by sand casting using a split pattern.
5. Cutting of a steel plate using oxyacetylene flame cutting /plasma cutting.
6. Making a butt joint on two stainless steel plates using TIG/MIG Welding.
7. An experiment on shearing operation.
8. An experiment on blanking operation.
9. An experiment on drawing operatin

Industrial Training – II Evaluation

BTMXI408	IT– II Evaluation	PROJ-2	-	1 Credits

Teaching Scheme:	Examination Scheme:
Lecture: --	Continuous Assessment: -- Mid Semester Exam: -- End Semester Exam:PR/OR

Control System Engineering

BTMXC601	PCC17	Control System Engineering	3-1-0	4 Credits

Teaching Scheme: Examination Scheme:	Teaching Scheme: Examination Scheme:
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 MarksMid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03hrs)

Pre-Requisites: None
Course Outcomes: At the end of the course, students will be able to**:**

CO1	Understand the basic concept of control engineering
CO2	Understand the modeling of linear invariant systems using transfer function and state space representations.
CO3	Understand the concept of stability and its assessment for linear time invariant systems.
CO4	Design simple feedback controllers
CO5	Represent the system in the state space form for the analysis

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	PO12
CO1	2	1	1		1			2				1
CO2	2	2	1		2							
CO3	2	1	1		1			2				1
CO4	3	2	3	1	2							2
CO5	3	1	2		2			3				3

Course Contents:

Unit 1: **[10 Hours]**

Introduction to control problem, Industrial Control examples, Transfer function, System with dead-time, System response, Control hardware and their models, potentiometers, synchro"s LVDT, dc and ac servomotors, tacho-generators, electrohydraulic valves, hydraulic servomotors, electro pneumatic valves, pneumatic actuators, closed-loop systems: Block diagram and signal flow graph analysis

Unit 2: **[10 Hours]**

Feedback control systems stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness. proportional, integral and derivative systems. feed-forward and multi-loop control configurations, stability concept, relative stability, Routh stability criterion.

Unit 3: **[11 Hours]**

Time response of second-order systems, steady-state errors and error constants, Performance specifications in time-domain, Root locus method of design., Lead and lag compensation.

Unit 4: **[11 Hours]**

Frequency-response analysis- Polar plots, Bode plot, stability in frequency domain, Nyquist plots, Nyquist stability criterion, Performance specifications in frequency-domain, Frequency-domain methods of design, Compensation & their realization in time & frequency domain, Lead and Lag compensation, Op-amp based and digital implementation of compensators, Tuning of process controllers, State variable formulation and solution

Unit 5: **[10 Hours]**

State variable Analysis- Concepts of state, state variable, state model, state models for linear continuous time functions, diagonalization of transfer function, solution of state equations, concept of controllability & observability.

Text Books/References:

1. Gopal. M., "Control Systems: Principles and Design", Tata McGraw-Hill, 1997.
2. Kuo, B.C., "Automatic Control System", Prentice Hall, sixth edition, 1993.
3. Ogata, K., "Modern Control Engineering", Prentice Hall, second edition, 1991.
4. Nagrath & Gopal, "Modern Control Engineering", New Age International, New Delhi.
   Ambikapathy A., Control System, Khanna Book Publishing Company, 2018

Design of Machine Elements

BTMXC 602	PCC18	Design of Machine Elements	3-1-0	4 Credits

Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03 hrs)

Pre-Requisites:

Course Outcomes: At the end of the course, students will be able to:

CO1	Recognize the stress state (tension, compression, bending, shear, etc.) and calculate the value of stresses & strains developed in the components.
CO2	Design of machine elements against static & fluctuating Loads
CO3	Design of components like shaft, key and select the rolling contact bearing for given application
CO4	Select belt drives & chain drives for given power rating
CO5	Design of different types of gears like Spur gears & Helical Gears etc.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		1				1				2
CO2	1	1				1		1		1		1
CO3	2	2	2	1		1		1		1		1
CO4	3	3	2	1		2		1		1		1
CO5	3	3	2	1		2		1		1		1

Course Contents:

Unit 1: Simple Stresses and Strains **[10 Hours]**

Mechanical properties of materials, analysis of internal forces, simple stresses and strains, stress-strain curve, Hooke"s law, modulus of elasticity, shearing, Hoop stress, Poisson"s ratio, volumetric stress, bulk modulus, shear modulus, relationship between elastic constants. Principal Stresses and Strains: Uni-axial stress, simple shear, general state of stress for 2-D element, ellipse of stress, principal stresses and principal planes, principal strains.

Unit 2: Design of Machine Elements against Static & Fluctuating Loads [10 Hours]
Theories of Failure (Yield and Fracture Criteria): Maximum normal stress theory, Maximum shear stress theory, Maximum distortion energy theory, comparison of various theories of failure, Direct loading and combined loading, Design against Fluctuating Loads: Stress concentration, stress concentration factors, fluctuating stresses, fatigue failure, endurance limit, notch sensitivity, approximate estimation of endurance limit, design for finite life and finite life under reversed stresses, cumulative damage in fatigue, Soderberg and Goodman diagrams, fatigue design under combined stresses.

Unit 3: Shafts & Bearings [11Hours]
Various design considerations in transmission shafts, splined shafts, spindle and axles strength, lateral and torsional rigidity, ASME code for designing transmission shaft. Types of Keys: Classification and fitment in keyways, Design of various types of keys.
Rolling Contact Bearings: Types, Static and dynamic load carrying capacities, Equivalent load, load and life relationship, selection of bearing life, Load factor, selection of bearing from manufacturer's catalogue, Cyclic loads and speeds, Design for probability of survival other than 90% Lubrication and mountings of rolling contact bearings.

Unit 4: Belt and Chain Drives [10 Hours]
Flat and V belts, Geometric relationship, analysis of belt tensions, condition for maximum power, Selection of flat and V belts from manufacturer's catalogue, Adjustment of belt tensions. Roller chains, Geometric relationship, polygonal effect, power rating of roller chain, sprocket wheels, and Silent chains.

Unit 5: Gears [11 Hours]
Spur Gear: Terminology of spur gear, Standard system of gear tooth force analysis, gear tooth failures, Selection of materials Constructional, Number of teeth, Face with, Beam strength equation, Effective load on gear tooth, Estimation of module based on beam strength. Design for maximum power capacity, Lubrication of gears.
Helical Gears: Terminology, Virtual number of teeth, Tooth proportions, Force analysis, Beam strength equation, Effective load on gear tooth, Wear strength equation.

Texts:
1. S. Ramamrutham, "Strength of Materials", Dhanpat Rai and Sons, New Delhi.
2. F. L. Singer, Pytle, "Strength of Materials", Harper Collins Publishers, 2002.
3. S. Timoshenko, "Strength of Materials: Part-I (Elementary Theory and Problems)", CBS Publishers, New Delhi.
4. V. B. Bhandari, "Design of Machine Elements", Tata McGraw Hill Publications, NewDelhi, 2008.
5. R. L.Nortan, "Machine Design: An Integrated Approach", Pearson Education Singapore, 2001

References:

1. E. P.Popov, “Introduction to Mechanics of Solid”, Prentice Hall, 2nd edition, 2005.
2. S. H. Crandall, N. C. Dahl, T. J. Lardner, “An introduction to the Mechanics of Solids”, Tata McGraw Hill Publications, 1978.
3. S. B. Punmia, “Mechanics of Structure”, Charotar Publishers, Anand.
4. R. C. Juvinall, K. M. Marshek, “ Fundamental of machine component design”, John Wiley & Sons Inc., New York, 3rd edition, 2002.
5. B. J. Hamrock, B. Jacobson and Schmid Sr., “Fundamentals of Machine Elements”, International Edition, New York,2nd edition, 1999.
6. A. S. Hall, A. R. Holowenko, H. G .Langhlin ,“Theory and Problems of Machine Design”, Schaum‟s Outline Series, Tata McGrawHill book Company,NewYork,1982.
7. J. E. Shigley and C. Mischke, “Mechanical Engineering Design”, Tata McGrawHill Publications,7th edition, 2004.
8. M. F.Spotts, “Design of Machine Elements”,Prentice Hall of India, New Delhi.

Elective III

Intelligent System and Control

BTMXPE603A	PEC3	Intelligent system and Control	3-0-0	3 Credits

Teaching Scheme:	Teaching Scheme: Examination Scheme:
Lecture: 3 hrs/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03hrs)

Pre-requisite:

Course Outcome (CO): On the successful completion of the course the students will be able to

CO1	Develop Neural Networks, Fuzzy Logic, and Genetic algorithms.
CO2	Implement soft computing to solve real-world problems mainly pertaining to control system applications.
CO3	Classify the network as per application
CO4	Understanding of genetic algorithm
CO5	State crisp and fuzzy set

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1			1			1				2
CO2	2	3	1									3
CO3	2	2	1		2			2				3
CO4	3	2		1				1				2
CO5	3	2	1	1				1				2

Course comtent

Unit1: Introduction to Intelligent Control **[7 Hours]**

Introduction and motivation, Approaches to intelligent control, Architecture for intelligent control.Symbolic reasoning system, rule-based systems, the AI approach. Knowledge representation.Expert systems.

Unit 2: Concept of Artificial Neural Networks: **[8Hours]**
Basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feed forward Multilayer Perceptron. Learning and training the neural network. Data Processing: Scaling, Fourier transformation, principal-component analysis.

Unit 3: Networks: **[8 Hours]**
Hopfield network, Self-organizing network and Recurrent network. Neural Network based controller Case studies: Identification and control of linear and nonlinear dynamic systems using Mat lab-Neural Network toolbox. Stability analysis of Neural-Network interconnection systems.

Unit 4: Genetic Algorithm: **[8 Hours]**
Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques like tabu search and ant-colony search techniques for solving optimization problems.

Unit 5: **Introduction to crisp sets and fuzzy sets:** **[8 Hours]**
Basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Fuzzy logic control for nonlinear time-delay system. Implementation of fuzzy logic controller using Matlab fuzzylogic toolbox. Stability analysis of fuzzy control systems.

Text Book :-

1. Simon Haykins, Neural Networks: A comprehensive Foundation, Pearson Edition, 2003.
2. T.J. Ross, Fuzzy logic with Fuzzy Applications, Mc Graw Hill Inc, 1997.
3. David E Goldberg, Genetic Algorithms.

Reference Books

1. M.T. Hagan, H. B. Demuth and M. Beale, Neural Network Design, Indian reprint, 2008.
2. Fredric M. Ham and Ivica Kostanic, Principles of Neuro computing for science andEngineering, McGraw Hill, 2001.
3. N. K. Bose and P. Liang, Neural Network Fundamentals with Graphs, Algorithms, and Applications, Mc – Graw Hill, Inc. 1996.
4. Yung C. Shin and Chengying Xu, Intelligent System – Modeling, Optimization andControl, CRC Press, 2009.
5. N. K. Sinha and Madan M Gupta, Soft computing & Intelligent Systems – Theory & Applications, Indian Edition, Elsevier, 2007.
6. Witold Pedrycz, Fuzzy Control and Fuzzy Systems, Overseas Press, Indian Edition, 2008.

Elective III

Adoptive and predictive controls in Mechatronic systems

BTMXPE603B	PEC3	Adoptive and predictive controls inMechatronic systems	3-0-0	3 Credits

Teaching Scheme:	**Teaching Scheme: Examination Scheme:**
Lecture: 3 hrs/week	Continuous Assessment: 20 MarksMid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03hrs)

Pre-Requisite:

Course Outcome: On the successful completion of the course the students will be able to

CO1	Understand the time varying systems
CO2	Learn the principles of predictive controllers
CO3	Use characteristics of Predictive control and its application
CO4	Understand the adaptive control system
CO5	State Self tuning regulators and model reference adaptive systems

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1			1			1				3
CO2	2	2	1									2
CO3	3	2	1		2			1				2
CO4	1	2		1				1				2
CO5	3	2	1	1				1				3

Course Content:

Unit 1: Introduction **[8 Hours]**

Introduction into time-varying systems, Model identification

Unit 2: Introduction of Predictive Control **[8 Hours]**
Basic principles of predictive controllers, Predictive control for linear systems

Unit 3: Characteristics and application of Predictive Control **[8 Hours]**
Stability and robustness of predictive control systems, Predictive control of nonlinear systems

Unit 4: Introduction to Adaptive Control **[8 Hours]**
Development of adaptive control problem-The role of Index performance (IP) in adaptive systems- Development of IP measurement process model.

Unit 5: Self tuning regulators and model reference adaptive systems : **[8Hours]**
Introduction - Pole placement design-Indirect Self-tuning regulators Continuous time Self-Tuners - Direct self tuning regulators - Linear quadratic self - Tuning regulators - Adaptive predictive control. The MIT rule – Determination of Adaptation Gain – Design of MRAS using Liapunov theory – BIBO Stability – Applications to Adaptivecontrol- Model Free Adaptive Control

Textbook(s)

1. Karl J Astrom and Bjorn Wittenmark, "Adaptive Control",Pearson education Inc., New Delhi, Second Edition, 2008.
2. J.M. Maciejowski: Predictive Control with Constraints, 2001

S. Grüne, L. Pannek: Nonlinear Model Predictive Control, 2011

Reference Books

Yoan D. Landu - Adaptive Control - Model ReferenceApproach, Marcel Dekker HSU and Meyer - Modern Control. Principles andApplications, McGraw Hill.

Elective III

Virtual Instrumentation

BTMXPE 603C	PEC3	Virtual Instrumentation	3-0-0	3 Credits

Teaching Scheme:	**Teaching Scheme: Examination Scheme:**
Lecture: 3 hrs/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03hrs)

Pre-Requisite:

Course Outcome (CO): On the successful completion of the course the students will be able to

CO1	Understand Virtual Instrument concepts
CO2	Study the various tools in graphical programming
CO3	Design a Virtual interface using graphical programming
CO4	Develop systems for real-time signal acquisition and analysis
CO5	Implement and design data acquisition systems for practical applications
CO6	Suggest solutions for automation and control applications using virtual instrumentation.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1			1			1				3
CO2	2	2	1									3
CO3	2	1	1		2			1				2
CO4	1	2		1				1				3
CO5	3	1	1	1				1				2
CO6												

Course Contents:

Unit 1: Introduction to Virtual Instrumentation **[8 Hours]**

Conventional instruments, Virtual Instruments - Architecture, Physical quantities and analog interfaces - hardware and software - user interfaces - advantages of virtual instrumentation over conventional instruments, Graphical programming languages.

Unit 2: Graphical Programming Environment **[8 Hours]**

Concepts of graphical programming – Concept of VIs and sub VIs – Display types – Digital – Analog – Chart – Oscilloscope types.

Unit 3: Graphical Programming Control Structures **[8 Hours]**

Data flow programming - modular programming, Loops – local and global variables - Caseand sequence structures – Types of data – Arrays – Formulate nodes - String and file I/O. LabVIEW: Basic arithmetic operations, Boolean operations.

Unit 4: Cluster of Instruments in Interfacing Systems **[8 Hours]**

Interfacing of external instruments to a PC – RS 232C, RS – 422, RS 485 and USB standards – IEEE 488 standard – introduction to bus protocols of MOD bus and CAN bus, Interfacingthe protocols with the virtual environment.

Unit 5: Real Time controller design **[8 Hours]**

Real time controller Designs using Virtual Instrumentation Software - ON/OFF controller –P-I-D controller – Proportional controller – Modeling and basic control of level and reactor processes – Case studies on development of supervisory control in VI

Text Book(s)

1.Sanjay Gupta, Joseph John, Virtual Instrumentation using LabVIEW, Tata McGrawHill, New Delhi, 2010.

Reference Books

1. Johnson G, Jennings R, LabVIEW Graphical Programming, Tata McGraw Hill, New York, 2006.
2. Jovitha Jerome, Virtual Instrumentation using LabVIEW, PHI Learning Pvt. Ltd, NewDelhi, 2010.

Elective IV

Computer Integrated Manufacturing

BTMXPE604A	PEC4	Computer Integrated Manufacturing	3-0-0	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 3 hrs/week Tutorial: -	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs.)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understanding the CAD, CAM and CIM.
CO2	Learn CAPP and MRP
CO3	Understand the part coding in cellular Manufacturing
CO4	List Flexible Manufacturing System and Automated Guided Vehicle System.
CO5	State industrial robotics

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1			1			1				2
CO2	2	2	1									2
CO3	3	2	1		2			1				2
CO4	2	2		1				1				2
CO5	3	2	1	1				1				3

Course Contents:

Unit 1: Introduction **[07 Hours]**

Brief introduction to CAD and CAM; Manufacturing Planning, Manufacturing control Introduction to CAD/CAM; Concurrent Engineering - CIM concepts; Computerized elements of CIM system; Types of production - Manufacturing models and Metrics; Mathematical models of Production Performance; Simple problems; Manufacturing Control; Simple Problems; Basic Elements of an Automated system; Levels of Automation; Lean Production and Just-In Time Production.

Unit 2: Production Planning and Control and CAPP **[08 Hours]**

Process planning; Computer Aided Process Planning (CAPP); Logical steps in Computer Aided Process Planning; Aggregate Production Planning and the Master Production Schedule; Material Requirement planning; Capacity Planning- Control Systems-Shop Floor Control Inventory Control; Brief on Manufacturing Resource Planning-II (MRP-II) & Enterprise Resource Planning (ERP).

Unit 3: Cellular Manufacturing **[08 Hours]**

Group Technology (GT), Part Families; Parts Classification and coding; Simple Problems in Opitz Part Coding system; Production flow Analysis; Cellular Manufacturing; Composite part concept; Machine cell design and layout; Quantitative analysis in Cellular Manufacturing; Rank Order Clustering Method - Arranging Machines in a GT cell.

Unit 4: Flexible Manufacturing System (FMS) and Automated Guided Vehicle System (AGVs) **[08 Hours]**

Types of Flexibility - FMS; FMS Components; FMS Application & Benefits; FMS Planning and Control– Quantitative analysis in FMS; Simple Problems. Automated Guided Vehicle System (AGVS); AGVS Application; Vehicle Guidance technology; Vehicle Management & Safety.

Unit 5: Industrial Robotics **[08 Hours]**

Robot Anatomy and Related Attributes; Classification of Robots- Robot Control systems; End Effectors; Sensors in Robotics; Robot Accuracy and Repeatability - Industrial Robot Applications; Robot Part Programming; Robot Accuracy and Repeatability; Simple Problems.

Texts:

1. Mikell.P.Groover "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India, 2008.
2. Radhakrishnan P, Subramanyan S.and Raju V., "CAD/CAM/CIM", 2nd Edition, NewAge International (P) Ltd, New Delhi, 2000

Open Elective II
Industrial Engineering

BTMXOE605F	OEC2	Industrial Engineering	3-0-0	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 3 hrs/week Tutorial: -	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Prerequisite:

Course Outcome: At the end of the course, students will be able to:

CO1	Understanding the Principles of Industrial Management
CO2	Learn different manufacturing systems.
CO3	Understanding the facilities and logistics in the industry
CO4	Describe the importance of Human Factors, Ergonomics, and Safety
CO5	State different planning tools

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2					2				3
CO2	3	2	1					2				3
CO3	3	2	2			1						2
CO4	3	2	2			2		1			2	3
CO5	3	2	2			2		1			2	3

Course Content:

Unit 1: Introduction **[8 Hours]**

Chronological Developments in IE, Objectives, & Functions of IE, Industrial Management - Principles (e.g., planning, organizing, motivational theory), Tools of management (e.g., MBO, Reengineer in organizational structure), Project management (e.g., scheduling, PERT, CPM), Productivity measures,

Unit 2: Manufacturing, Production, and Service Systems **[7 Hours]**

Manufacturing systems (e.g., cellular, group technology, flexible), Process design (e.g., resources, equipment selection, line balancing), Inventory analysis (e.g., EOQ, safety stock), Forecasting,

Scheduling (e.g., sequencing, cycle time, material control), Aggregate planning, Production planning (e.g., JIT, MRP, ERP), Lean enterprises, Automation concepts (e.g., robotics, CIM), Sustainable manufacturing (e.g., energy efficiency, waste reduction), Value engineering

Unit 3: Facilities and Logistics **[8 Hours]**

Flow measurements and analysis (e.g., from/to charts, flow planning), Layouts (e.g., types, distance metrics, planning, evaluation), Location analysis (e.g., single- and multiple-facility location, warehouses), Process capacity analysis (e.g., number of machines and people, trade-offs), Material handling capacity analysis, Supply chain management and design

Unit 4: Human Factors, Ergonomics, and Safety **[8 Hours]**

Hazard identification and risk assessment, Environmental stress assessment (e.g., noise, vibrations, heat), Industrial hygiene, Design for usability (e.g., tasks, tools, displays, controls, user interfaces), Anthropometry, Biomechanics, Cumulative trauma disorders (e.g., low back injuries, carpal tunnel syndrome), Systems safety, Cognitive engineering (e.g., information processing, situation awareness, human error, mental models)

Unit 5: Quality and Systems Engineering Quality **[8 Hours]**

Six sigma, Management and planning tools (e.g., fishbone, Pareto, QFD, TQM), Control charts, Process capability and specifications, Sampling plans, Design of experiments for quality improvement, Reliability engineering

Systems Engineering:Requirement"s analysis, System design, Human systems integration, Functional analysis and allocation, Configuration management, Risk management, Verification and assurance, System life-cycle engineering

Text Book(s)

1.*Introduction to Industrial Engineering* by Avraham Shtub, Yuval Cohen, 2nd Edition, 2016, CRC Press, Boca Raton. ISBN: 9781498706018

Reference Books

1.*Handbook of Industrial Engineering: Technology and Operations Management*, Editor - GavrielSalvendy, Print ISBN:9780471330578, Online ISBN:9780470172339, DOI:10.1002/9780470172339, Copyright © 2001 John Wiley & Sons, Inc.

Computer Aided Design Lab

BTMXCL 606	PCC19	Computer Aided Design Lab	0-0-2	1 credit

Teaching Scheme	Examination Scheme
Practical 2 hours	Continuous Assessment: 60 Marks End Semester Evaluation: 40 Marks

Prerequisite:

Course Outcome: At the end of the course, students will be able to:

CO1	
CO2	
CO3	
CO4	
CO5	

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

List of Practical's/Experiments

1. One Assignment based on drafting of a simple mechanical component using Autocad
2. One assignment based on (fully constrained) sketching using any of the CAD software such as CATIA, Creo, NX CAD, Solidworks, etc.
3. One assignment based on 3D modelling of simple mechanical components using any of the CAD software such as CATIA, Creo, NX CAD, Solidworks, Fusion 360, 3D experience, etc.
4. One assignment based on assembly of components (minimum four components should be available in the assembly) using any of the CAD software such as CATIA, Creo, NX CAD, Solidworks, Fusion 360, 3D experience, etc. (can be given in group of 4 to five students)
5. One assignment based on automated drafting of simple mechanical components using any of the CAD software such as CATIA, Creo, NX CAD, Solidworks, Fusion 360, 3D experience, etc. (The component modelled in assignment 3 above can be used for this assignment)

Control System Engineering Lab

BTMXCL 607	PCC19	**Control System Engineering Lab**	0-0-2	1credits

Practical Scheme:	**Examination Scheme:**
Practical: 2 hrs/week	Continuous Assessment: 60 Marks External Exam: 40 Marks

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to**:**

CO1	To Develop the mathematical model of the physical systems.
CO2	To Analyze the response of the closed and open loop systems.
CO3	To Analyze the stability of the closed and open loop systems.
CO4	To Design the various kinds of compensator.
CO5	To Develop and analyze state space models.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

List of Experiments: (Any Eight)

1. Different Toolboxes in MATLAB, Introduction to Control Systems Toolbox or its equivalent open source freeware software like Scilab.
2. Determine transpose, inverse values of given matrix.
3. Plot the pole-zero configuration in s-plane for the given transfer function.
4. Determine the transfer function for a given closed loop system in block diagram representation.
5. Plot Module step response of given transfer function and find delay time, rise time, peak time and peak overshoot.
6. Determine the time response of the given system subjected to any arbitrary input.

7. Plot root locus of given transfer function, locate closed loop poles for different values of k. Also find out Wd and What for a given root.
8. Create the state space model of a linear continuous system.
9. Determine the State Space representation of the given transfer functions.
10. Plot bode plot of given transfer function. Also determine the relative stability by measuring gain and phase margins.
11. Determine the steady state errors of a given transfer function.
12. Plot Nyquist plot for given transfer function and to discuss closed loop stability. Also determine the relative stability by measuring gain and phase margin.

Text Books/References:

1. Gopal. M., “Control Systems: Principles and Design”, Tata McGraw-Hill, 1997.
2. Kuo, B.C., “Automatic Control System”, Prentice Hall, sixth edition, 1993.
3. Ogata, K., “Modern Control Engineering”, Prentice Hall, second edition, 1991.
4. Nagrath & Gopal, “Modern Control Engineering”, New Age International, New Delhi.
5. Ambikapathy A., Control System, Khanna Book Publishing Company, 2018.

Technical Project for Community Services (TPCS)

BTMXP609	Technical Project for Community Services (TPCS)	PROJ-5	0L-0T-2P	1 Credits

Teaching Scheme:	Examination Scheme:
Practical: 2 hrs/week	Continuous Assessment: 60 Marks End Semester Exam: 40 Marks

Students are expected to carry out a mini project under a project guide based on the chosen area. The project may be prototype/software based which may demonstrate Engineering application or community service. After completion the project work it is necessary that student should prepare a project report under the supervision of the assign guide and present before the committee.