UNIVERSITY OF MUMBAI
No. UG/135 of 2016-17

CIRCULAR:-

A reference is invited to the syllabi relating to the Master of Engineering (Instrumentation Engineering) degree course **vide** this office Circular No.UG/40 of 2013-14, dated 27th May, 2013 and the Principals of affiliated Colleges in Engineering are hereby informed that the recommendation made by Ad-hoc Board of Studies in Electrical Engineering at its meeting held on 8th July, 2016 has been accepted by the Academic Council at its meeting held on 14th July, 2016 **vide** item No. 4.11 and that in accordance therewith, the revised syllabus as per Choice Based Credit System for Master of Engineering (Instrumentation Engineering) Sem. I to IV), which is available on the University's web site (www.mu.ac.in) and that the same has been brought into force with effect from the academic year 2016-17.

8/11/16

(Dr.M.A.Khan)
REGISTRAR

MUMBAI – 400 032
9th November, 2016

To,
The Principals of affiliated Colleges in Engineering.

A.C/ 4.11/14/07/2016.

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No. UG/135-A of 2016 MUMBAI-400 032 9th November, 2016

Copy forwarded with compliments for information to:-

1. The Dean, Faculty of Technology,
2. The Chairmen, Ad-hoc Board of the Studies in Electrical Engineering
3. The Director, Board of College and University Development,
4. The Controller of Examinations,
5. The Co-Ordinator, University Computerization Centre.

8/11/16

(Dr.M.A.Khan)
REGISTRAR

... PTO

AC 14/07/2016
Item No. 4.11

UNIVERSITY OF MUMBAI

Revised Syllabus for the

M.E. Instrumentation Engineering

(As per Choice Based Credit and Grading System with effect from the academic year 2016-2017)

From Co-ordinator's Desk:

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 that, each Board of Studies shall prepare some Program Educational Objectives (PEO's) and give freedom to affiliated Institutes to add few (PEO's) and course objectives and course outcomes to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. It was also resolved that, maximum senior faculty from colleges and experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology, and developed curriculum accordingly. In addition to outcome based education, **Choice Based Credit and Grading System** is also introduced to ensure quality of engineering education.

Choice Based Credit and Grading System enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning not in teaching. 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 Faculty of Technology has devised a transparent credit assignment policy adopted ten points scale to grade learner's performance. Choice Based Credit and Grading System were implemented for First Year Master of Engineering from the academic year 2016-2017. Subsequently this system will be carried forward for Second Year Master of Engineering in the academic year 2017-2018.

Dr. Suresh K. Ukarande
Co-ordinator,
Faculty of Technology,
Member - Academic Council
University of Mumbai, Mumbai

Preamble:

The overall technical education in our country is changing rapidly in manifolds. Now it is very much challenging to maintain the quality of education with its rate of expansion. To meet present requirement a systematic approach is necessary to build the strong technical base with the quality. Accreditation will provide the quality assurance in higher education and also to achieve recognition of the institution or program meeting certain specified standards. The main focus of an accreditation process is to measure the program outcomes, essentially a range of skills and knowledge that a student will have at the time of graduation from the program that is being accredited. Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

I, as Chairman, Board of Studies in Electrical Engineering of University of Mumbai, happy to state here that, Program Educational Objectives (PEOs) were finalized for post-graduate program in Instrumentation Engineering, more than ten senior faculty members from the different institutes affiliated to University of Mumbai were actively participated in this process. Few PEOs were finalized for post-graduate program in Instrumentation Engineering are listed below;

Program Educational Objectives (PEOs)

- To create the competent & skilled engineers to ensure them the careers and employment and in this way fulfill the requirement of Multinational industries.
- To develop the strong ability in data analysis & their report towards an application for design and development of automation product & systems.
- Expose them by giving an opportunity as an individual as well as team.
- Inculcate professional and ethical attitude and ability to relate automation issues to society at large.
- Facilitate strong base of basic scientific & engineering knowledge with professional ethics, lifelong learning attitude society globally.
- Be successful innovative and entrepreneur in the automation field via consultancy work.

Program Outcomes (POs)

- Able to demonstrate & competent enough in basic knowledge in Mathematics, Engineering and Technology to obtain the solution of engineering problem.
- Have ability to formulate the engineering problem, design the setup for experimentation, analysis and interpretation of the result data, report preparation.
- Develop the competency to design an instrument system, automation systems, control systems, engineering software's, simulated model and solutions etc as per desired specification & requirement as applicable/useful to public/society.
- Demonstrate the ability to work on basic engineering discipline as well as multi-disciplinary engineering teams to achieve the solution of engineering problem.
- Strong competency in using modern engineering tools like MATLAB / Simulink,

LABVIEW/MultiSim for solution of control engineering problems.

- Able to use the acquired knowledge and professional skill and project as well as budget management towards betterment of the society.
- Understand the needs of the society worldwide in the context of his professional knowledge to ensure environmental safety and better sustainability.
- Capable to apply ethical principles with committed professional ethics and duties towards the solution of complex engineering problems.
- Motivate to work independently as well as a member of team or team leader in multi functionaries and diversified knowledge platforms.
- Develop an effective inter personnel communication skill at large with public and professional bodies. They will be able to comprehend the data and accordingly will prepare technical design details, datasheets, reports, documentation etc.
- Inculcate the lifelong learning in the purview of updates /upgrade in engineering and technology.
- Investigate the complex engineering problems using acquired knowledge in instrumentation engineering to develop industrial level solutions in the interest of society.

Dr. S. R. Deore,
Chairman,
Board of Studies in Electrical Engineering,
Member - Academic Council
University of Mumbai

Program Structure for
M.E. Instrumentation Engineering
University of Mumbai
(With Effect from 2016-17)

Semester I

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ISC101	Computational Techniques in Instrumentation Engineering	04	-	-	04	-	-	04
ISC102	Sensors and Measurement Systems	04	-	-	04	-	-	04
ISC103	Process Dynamics and Control	04	-	-	04	-	-	04
ISDLO101X	Department Level Optional Course-I	04	-	-	04	-	-	04
ILO101X	Institute Level Optional Course-I	03	-	-	03	-	-	03
ISL101	Laboratory-I	-	02	-	-	01	-	01
ISL102	Laboratory-II	-	02	-	-	01	-	01
Total		**19**	**04**	**-**	**19**	**02**	**-**	**21**

Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract. /Oral	Total
		Internal Assessment			End Sem.	Exam. Duration			
		Test1	Test 2	Avg.					
ISC101	Computational Techniques in Instrumentation Engineering	20	20	20	80	03	-	-	100
ISC102	Sensors and Measurement Systems	20	20	20	80	03	-	-	100
ISC103	Process Dynamics and Control	20	20	20	80	03	-	-	100
ISDLO101X	Department Level Optional Course-I	20	20	20	80	03	-	-	100
ILO101X	Institute Level Optional Course-I	20	20	20	80	03	-	-	100
ISL101	Laboratory -I	-	-	-	-	-	25	25	50
ISL102	Laboratory -II	-	-	-	-	-	25	25	50
Total		**100**	**100**	**100**	**400**	**-**	**50**	**50**	**600**

Program Structure for
M.E. Instrumentation Engineering
University of Mumbai
(With Effect from 2016-17)

Semester II

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ISC201	Modern Control Theory	04	-	-	04	-	-	04
ISC202	Applied Instrumentation for Process Industries	04	-	-	04	-	-	04
ISC203	Industrial Automation	04	-	-	04	-	-	04
ISDLO202X	Department Level Optional Course-II	04	-	-	04	-	-	04
ILO202X	Institute Level Optional Course-II	03	-	-	03	-	-	03
ISL201	Laboratory -III	-	02	-	-	01	-	01
ISL202	Laboratory –IV	-	02	-	-	01	-	01
Total		**19**	**04**	**-**	**19**	**02**	**-**	**21**

Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract. /Oral	Total
		Internal Assessment			End Sem.	Exam. Duration			
		Test1	Test 2	Avg.					
ISC201	Modern Control Theory	20	20	20	80	03	-	-	100
ISC202	Applied Instrumentation for Process Industries	20	20	20	80	03	-	-	100
ISC203	Industrial Automation	20	20	20	80	03	-	-	100
ISDLO202X	Department Level Optional Course-II	20	20	20	80	03	-	-	100
ILO202X	Institute Level Optional Course-II	20	20	20	80	03	-	-	100
ISL201	Laboratory-III	-	-	-	-	-	25	25	50
ISL202	Laboratory-IV	-	-	-	-	-	25	25	50
Total		**100**	**100**	**100**	**400**	**-**	**50**	**50**	**600**

Program Structure for
M.E. Instrumentation Engineering
University of Mumbai
(With Effect from 2016-17)

Semester III

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theor	Pract.	Tut.	Theory	Pract.	Tut.	Total
ISS301	Special Topic Seminar	-	06	-	-	03	-	03
ISD301	Dissertation–I	-	24	-	-	12	-	12
Total		-	30	-	-	15	-	15

Subject Code	Subject Name	Examination Scheme						
		Theory						
		Internal Assessment			End Sem. Exam.	Term Work	Pract. /Oral	Total
		Test1	Test 2	Avg.				
ISS301	Special Topic Seminar	-	-	-	-	50	50	100
ISD301	Dissertation–I	-	-	-	-	100	-	100
Total		-	-	-	-	**150**	**50**	**200**

Semester IV

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theor	Pract.	Tut.	Theory	Pract.	Tut.	Total
ISD401	Dissertation–II	-	30	-	-	15	-	15
Total		-	30	-	-	15	-	15

Subject Code	Subject Name	Examination Scheme						
		Theory						
		Internal Assessment			End Sem. Exam.	Term Work	Pract. /Oral	Total
		Test1	Test 2	Avg.				
ISD401	Dissertation–II	-	-	-	-	100	100	200
Total		-	-	-	-	**100**	**100**	**200**

Note:

- In case of Seminar, 01 Hour / week / student should be considered for the calculation of load of a teacher
- In case of Dissertation I, 02 Hour / week / student should be considered for the calculation of load of a teacher
- In case of Dissertation II, 02 Hour / week / student should be considered for the calculation of load of a teacher
- **End Semester Examination:** In all six questions to be set, each of 20 marks, out of these any four questions to be attempted by students. Each question will comprise of mixed questions from different units of the subjects.

Subject Code	Department Level Optional Course-I	Subject Code	Department Level Optional Course-II
ISDLO1011	Applied Biomedical Instrumentation	ISDLO2021	Fractional Order Modeling and Control
ISDLO1012	Design of Embedded System	ISDLO2022	Advanced Nuclear Instrumentation
ISDLO1013	Advanced Digital Signal Processing	ISDLO2023	Wavelets and Applications
ISDLO1014	Instrumentation for Non-conventional Energy Sources	ISDLO2024	Soft Computing Techniques
ISDLO1015	Applied Analytical Instrumentation	ISDLO2025	Instrumentation for Environmental Analysis
ISDLO1016	Fault Tolerant Control	ISDLO2026	Robotics and Automation

Subject Code	Institute Level Optional Course-I	Subject Code	Institute Level Optional Course-II
ILO1011	Product Lifecycle Management	ILO2021	Project Management
ILO1012	Reliability Engineering	ILO2022	Finance Management
ILO1013	Management Information System	ILO2023	Entrepreneurship Development and Management
ILO1014	Design of Experiments	ILO2024	Human Resource Management
ILO1015	Operation Research	ILO2025	Professional Ethics and Corporate Social Responsibility (CSR)
ILO1016	Cyber Security and Laws	ILO2026	Research Methodology
ILO1017	Disaster Management and Mitigation Measures	ILO2027	IPR and Patenting
ILO1018	Energy Audit and Management	ILO2028	Digital Business Management
		ILO2029	Environmental Management

Subject Code	Subject Name	Credits
ISC101	COMPUTATIONAL TECHNIQUES IN INSTRUMENTATION ENGINEERING	04

Course Objectives:

- To develop understanding and application of fundamental techniques involved in the analysis and computation of Instrumentation engineering.
- To train the students with mathematics needed to analyze and solve engineering problems.
- To build up the ability to apply the concepts of Matrix theory and Linear programming.
- To familiarize numerical methods pertaining to control engineering problems.
- To make acquainted the students in calculus of variations and solve problems using integral transforms associated with engineering applications.

Course Outcomes:

- Able to acquire adequate knowledge in matrix theory and its application.
- Capable to solve numerical methods for differential equations.
- Able to apply the basic concepts and methods of probability and statistics.
- Demonstrate concept of integral transforms and their application areas.
- Improve the problem evaluation skills.
- Able to select an appropriate method to solve a practical problem.

Module	Detailed content	Hours
	Prerequisite: Review of matrix theory, Basic concepts of vector spaces, Solution of linear ordinary differential equations, Elementary integral and differential calculus, Revision of axioms of probability, Introduction to the concept of function.	
1	**Matrix computation:** Determinant, rank, Norm, inverse, Transpose of matrix, Eigen values and Eigen vectors, Decomposition: LU, QR, Cholesky, Schur decomposition, Eigenvalue decomposition, Biconjugate decomposition.	08
2	**Vector spaces:** Subspaces, Linear combinations and subspaces spanned by a set of vectors, Linear dependence and Linear independence, Inner product, Orthogonality, Gram – Schmidt orthonormalization.	06
3	**Numerical methods for algebraic and differential equations:** Solution of algebraic equations- least square method, Gauss-Jordan method, Gauss- Seidal method, Gauss elimination method, Newton-Raphson method, Euler's method, Runge-Kutta method, Numeric integration and differentiation - Trapezoidal rule, Simpson's rule, Adaptive integration.	10
4	**Calculus of Variation:** Concept of variation and its properties – Euler's equation, Functional dependant on first and higher order derivatives, Functional dependant on functions of several independent variables, Variation problems with moving boundaries, problems with constraints, Direct methods: Ritz and Kantorovich methods.	08

5	**Probability and random variable:** Probability space, Sample spaces, Conditional probability, Bayes' theorem, Random variable, Probability distribution function, Probability density function, Distributions- Binomial, Poisson, Normal, Exponential, Uniform.	08
6	**Integral Transforms:** Laplace transform, Z-Transform, Fourier transform, Fast fourier transform, Discrete fourier transform, Wavelet transform, Mellin transform, Hankel transform.	08

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Strang G., "Linear Algebra and its Application", Fourth edition, 1996.
2. Horward Anton “Elementary Linear Algebra”, 11th Edition, Wiley Publications, 2013.
3. Michael T. Heath, "Scientific computing- An Introduction Survey", McGraw Hill,1997.
4. Erwin Kreyszig, "Advanced Engineering Mathematics", 9th Edition, John Wiley and Sons, INC, 2006.
5. Davies B., "Integral Transforms and their applications," 2nd edition, New York, Springer-Verlag, 1985.
6. Murray Spiegal, John Schiller and R. Alu Srinivasan, "Probability and Statistics", Tata Mc-Graw - Hill edition, New Delhi, 2004.
7. Walpole R.E., Myers R.H. and Myers S.L., "Probability and Statistics for Engineers and Scientist", Prentice Hall Inc., New Jercy, 1998.
8. G.H. Golub and C.F. Van Loan, "Matrix computations", 4th edition, John Hopkins University press, 2007.
9. Steven C. Chapra, "Applied Numerical methods with MATLAB for engineers and scientists", McGraw Hill, third edition, 2012.
10. S.S. Sastry, "Introductory Methods of Numerical Analysis", Prentice-Hall of India Private Limited, 5 thedition, 2012.

Subject Code	Subject Name	Credits
ISC102	SENSORS AND MEASUREMENT SYSTEMS	04

Course Objectives:

- To introduce the resistive, inductive and capacitive transducers and their transduction principles.
- To educate on magnetic transducer elements.
- Study of acoustic, mechanical and flow metering elements, their working principles.
- To familiar them various optical sensors, their transduction principles and their applications.
- To create awareness of advanced and miniature sensors and their applications.

Course Outcomes:

- Be able to interpret and formulate design specifications for various transducers that meet accuracy and sampling speed requirements.
- Able to explain the principles of operation of sensors including temperature transducers, flow transducers and pressure transducers.
- Demonstrate principles of analog and digital signal and data processing, including Amplifiers, filters and A-D conversion techniques. Understand sources and measures of error in instrumentation systems.
- Be able to design, construct, and verify an instrumentation system to meet desired specifications, with the aid of computer-aided design techniques.
- Be familiar with safety issues concerning design of instrumentation, including the effects of electric current through tissue and defibrillation.

Module	Detailed content	Hours
	Prerequisite: Overview of conventional sensors - Resistive, Capacitive, Inductive, Thermal, Piezoelectric, Magneto strictive and Hall effect sensors - Static and Dynamic characteristics and specifications - Measurements and Measurement system.	
1	**Basic Measuring Sensor Dynamics:** Mathematical model of variable resistive transducers: Potentiometer loading effect, Strain gauge analysis, Variable inductive transducers and its circuit analysis, Variable capacitive transducers: Capacitive pickups, its model, Capacitive transducer signal processing, Piezoelectric transducers: Its equivalent circuit, Displacement to pressure system (Flapper and nozzle system).	10
2	**Mathematical model of Measurement system:** Generalized mathematical model of measurement system: Zero, I and II order electrical and non-electrical system and its response to impulse, step, ramp and sinusoidal input, Mechanical translational and rotational system, Thermal system, Liquid level system, Pneumatic system.	08
3	**Process Measuring Sensor Dynamics I:** Mathematical model and analysis of flow measuring device: Mass and density flow meter, Corriolis type mass flow meter, Venturi meter, Vortex meter, Magnetic flow meter, orifice and rotameter, Mathematical model, Analysis and compensation of temperature measuring devices: high speed	10

	thermocouples, RTD, Pulse excitation techniques, Photovoltaic sensor.	
4	**Process Measuring Sensor Dynamics II:** Mathematical model and signal processing of pressure measurement**:** Manometer dynamics, Elastic pressure pickups- diaphragm type, Strain gauge pressure pickups, Diffused sensor transducers and auto reference techniques, Differential presuure transmitters, Model of force balance pressure sensor, Mathematical model and analysis of displacement measurement: Strain gauge, Potentiometer, LVDT.	10
5	**Introduction to Transmitters:** Two wire, three wire and four wire transmitters, Smart and intelligent Transmitters. Design of transmitters.	04
6	**SMART Sensors and Nanotechnology:** Micro-sensors and smart sensors: Block diagram, characteristics and applications, Nanotechnology: Discussion on nano sensors and MEMS application.	06

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. H.K.P Neubert, "Instrument Transducers Oxford Herman University Press Eighth Impression 2008.
2. B. G. Liptak, "Instrument Engineers Handbook", Vol. I and II, Third Edition, Chilton and Book Company, 1990.
3. C. D. Johnson," Process Control Instrumentation Technology", Fourth Edition, PHI, 1996
4. Andrew and Williams, "Applied Instrumentation in Process Industries", Vol. I, II, III, IV, Gulf Publishing Company, 1979.
5. D. M. Considine, "Process/Industrial Instruments and Control Handbook", Fourth Edition, McGraw-Hill Inc., 1993.
6. John P. Bentley, "Principles of Measurement Systems", Addison-Wesley publication, 1999.
7. T. R. Padmanabhan, "Industrial Instrumentation: Principles and Design", Springer-Verlag Publications, 1999.
8. B. C. Nakra and K. K. Choudhari, "Instrumentation: Measurement and Analysis", Tata McGraw Hill Pub, 1985.
9. nE.A. Doebelin, "Measurement Systems – Applications and Design", Tata McGraw Hill, New York, 2000.

10. A. K. Sawhney, "A course in Electrical & Electronic Measurement and Instrumentation", Dhanpat Rai and Co (P) Ltd., 2004.
11. R. Frank "Understanding smart sensors", Artech house, (1996) .
12. D. Patranabis"Princples of Industrial Instrumentation" H.K.P Neubert “Instrument Transducers”, Oxford Herman University Press Eighth Impression 2008.

Subject Code	Subject Name	Credits
ISC103	PROCESS DYNAMICS AND CONTROL	04

Course Objectives:

- To teach the fundamental of mathematical modeling of real-time systems and design various controller modes and tuning methods.
- To develop skill for design of single loop and multi loop control schemes.
- To brief different enhancement in control and tuning strategies.
- To develop approach for applying the multivariable control schemes for various applications.
- Train the student for Plant wide control.

Course Outcomes:

- Ability to obtain the mathematical model of real-time first and higher order systems and to design various controller modes with appropriate tuning.
- Expose to design and implement conventional and advanced control schemes for various processes.
- Ability to enhance the performance of single and multi-loop and multivariable control systems.
- Ability to demonstrate multi-loop controller for various applications.
- Ability to develop plant wide control system.

Module	Detailed content	Hours
	Prerequisite: Process control fundamental, Control actions, concept of Single and multi- loop control, Multivariable system and control	
1	**Process Dynamics & Control Actions:** Need for process control – Hierarchical decomposition of control functions - Continuous and batch processes, Self-regulation - Interacting and non-interacting systems - Mathematical model of Level, Flow and Thermal processes – Lumped and Distributed parameter models – Linearization of nonlinear systems - Characteristic of ON-OFF, P, P+I, P+D and P+I+D control modes.	8
2	**PID Controller Tuning – Single Loop Regulatory Control:** Evaluation criteria – IAE, ISE, ITAE and ¼ decay ratio – Tuning: Process reaction curve method: Z-N and Cohen-Coon methods, Continuous cycling method and damped oscillation method – optimization methods – Auto tuning.	6
3	**Enhancement to Single Loop Regulatory Control & Model Based Control Schemes:** Cascade control – Split-range - Feed-forward control – Ratio control – Inferential control — override control - Smith predictor control scheme - Internal Model Controller - IMC PID controller – Single Loop Dynamic Matrix Control – Generalized Predictive Control, Model Predictive Control.	10
4	**Multivariable Systems & Multi-Loop Regulatory Control:** Multivariable Systems – Transfer Matrix Representation – Poles and Zeros of MIMO System – Multivariable frequency response analysis Directions in multivariable systems - Singular value decomposition - Multi-loop Control - Introduction – Process Interaction – Pairing of Inputs and Outputs -The Relative Gain Array (RGA) –Properties and	10

	Application of RGA - Multi-loop PID Controller – Biggest Log Modulus Tuning Method -Decoupling Control	
5	**Multivariable Regulatory Control & Case –Studies:** Introduction to Multivariable control – Multivariable PID Controller –Multivariable IMC – Multivariable Dynamic Matrix Controller -Multiple Model based Predictive Controller –Predictive PID Control – Case Study: Distillation Column, CSTR, Bioreactor, Four-tank system, pH, and polymerization reactor.	10
6	**Plant wide Control:** Introduction Plant wide control, Steady state and dynamic effect of recycle, Design example of Plant wide control.	04

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. B.Wayne Bequette, "Process Control: Modeling, Design, and Simulation", Prentice Hall of India, 2004.
2. Dale E. Seborg , Duncan A. Mellichamp , Thomas F. Edgar, and Francis J. Doyle, "Process Dynamics and Control", John Wiley and Sons, 3rd Edition, 2010.
3. Jose A. Romagnoli and Ahmet Palazoglu , "Introduction to Process Control", CRC Press, Taylor and Francis Group, Second Edition, First Indian Reprint, 2010.
4. Bela Liptak, "Process Control- Instrument Engineers Handbook", (Volume 2) Third Edition: CRC Press, Boca Raton London New York Washington D.C, February 15, 1995
5. George Stephanopolus, "Chemical Process Control", Pearson India, 2015.
6. William L. Luyben, Björn D. Tyréus, Michael L. Luyben, "Plantwide Process Control", McGraw-Hill, 1999.

Subject Code	Subject Name	Credits
ISDLO1011	APPLIED BIOMEDICAL INSTRUMENTATION	04

Course Objectives:

- To introduce about various instruments functionality and advanced techniques in biomedical instrumentation.
- To build adequate knowledge about measurement of various physiological parameters and to understand the fundamental principle and working of the biomedical instruments involved in the measurement.
- To gain basic knowledge about Bio-potentials, bioelectrodes and bioamplifiers and to give a complete exposure of various recording mechanism.
- To provide latest knowledge of special medical assistive and therapeutic equipment's and learn how to use that equipment's and servicing**.**
- To explain the fundamentals of different types of laser, its operations and applications in medical field.

Course Outcomes:

- Able to determine the origin of bio-potential, different types of electrodes used in bio-potential recording.
- Able to measure various physiological parameters and helps to design biomedical sensors.
- Ability to apply knowledge about physiotherapy and electrotherapy equipment, instruments dealing with kidney and bones.
- Inculcate knowledge of instruments used for sensory measurements, imaging equipments and diagnostics measurements.
- Demonstrate special medical assistive and therapeutic equipments and learn how to use that equipments and servicing.

Module	Detailed content	Hours
	Prerequisite: Structure of Cell, Origin of Bio-potential, Physiological Systems and Related Measurement, Structure of Heart, Electrical and Mechanical activity of Heart, Cardiovascular Measurement, Life support instruments, Imaging Techniques.	
1	**Introduction to Biomedical measurements:** Recording of membrane potential & Action potential, Contraction & excitation of smooth muscle, Electrocardiographic interpretation of cardiac muscle & cardiac arrhythmias, Physical characteristics of circulation, measurement of fluid volumes, osmosis & osmotic pressure, mechanism of pulmonary ventilation, Transmission & processing of signals in neuronal pools.	04
2	**Instrumentation for Diagnosis & Monitoring:** Electrocardiograph system, principles of vectoral analysis of vectocardiogram, Advancement in EEG signal processing, computerised patient	10

	monitoring system, Bio-potential electrodes- types and characteristics, Origin, recording schemes & analysis of biomedical using ECG, EEG, Pulse oximeter, Fetal monitor, Spirometer, Incubator, Opthamology.	
3	**Biotherauptic Instruments and Electrical safety aspects:** Defibrillator system, Nerve & Muscle Stimulator, Electrosurgical unit for cutting & coagulation of muscles, Shortwave diathermy, Hemodialysis machine, Ventilator, Anesthesia machine, Automated drug delivery systems, Human and Equipment safety, Physiological effects of electricity, Micro and macro shocks, thermal effects.	08
4	**Bio-Imaging Modality:** Advanced medical imaging techniques & modalities- Imaging with X-ray, principle and production of soft X-rays & hard X-rays, screen film & image intensifier system, Computed tomography imaging, CT image reconstruction, CT angiography, Optical coherence tomography, Radionuclide imaging, PET and SPECT systems, Infrared imaging, Clinical applications of thermography, Image acquisition in MRI, spin echo technique & spin relaxation technique.	10
5	**Biomedical Implants & Microsystems:** Implantable medical devices, Artificial valves, Cochlear implants, Cardiac pacemaker, Bio-prosthetic devices, Micro fabrication technologies for biomedical microsystems, micro-sensors for clinical applications, Biomedical micro-fluid systems.	10
6	**Bio-photonics:** Laser physics, fundamental of laser, types of laser, properties of lasers, Interaction of laser with tissue, Non-thermal & thermal effects, Overview of laser propagation in tissue, medical applications of laser for dermatology, ophthalmic, cardiology, dentistry, neurosurgery, Laser hazards & safety aspects, biological effects of laser, radiations safety exposure limits.	06

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Guyton, A.C. "Medical Physiology", 12th Edition, Saunders Publisher,Philadelphia, 2010.
2. Thyagarajan K, Ajoy K, Ghatak A, "Lasers Fundamentals and Applications", Second edition, Springer 2010.
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11. Kayvannajarian and Robert splinter, "Biomedical Signal and Image Processing", CRC Press, 2005.
12. John M.Semmlow, "Bio signal and Bio medical Image processing", CRC Press, 2004.
13. Joseph J. Carr and John M Brown,"Introduction to Biomedical Equipment Technology", Pearson Education, 2004.
14. Reza Fazel-Rezai, "Biomedical Engineering - From Theory to Applications", InTech Publisher, 2011.

Subject Code	Subject Name	Credits
ISDLO1012	DESIGN OF EMBEDDED SYSTEM	04

Course Objectives:

- To teach students to the modern embedded systems program such systems using a concrete platform.
- To emphasizes high-level tools and hardware/software trade-offs, rather than low-level assembly-language programming and logic design.
- To make them familiar with distinct fields of software and hardware design in a new unified approach.
- Expose them with trends and challenges, the design and use of single-purpose processors ("hardware") and general-purpose processors ("software"), describes memories and buses, and illustrates hardware/software tradeoffs, chip technologies and modern design tools.
- Develop skill to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

Course Outcomes:

- Ability to differentiate between the general computing system and the embedded system, also recognize the classification of embedded systems.
- Able to design ARM based and DSP based embedded systems.
- Demonstrate the concept of operating system and real time embedded systems using the concepts of RTOS.
- Ability to expose the concept of Internet of things and its applications.
- Analyze various examples of embedded systems based on ARM processor and familiar with advanced processor.

Module	Detailed content	Hours
	Prerequisite: Fundamentals of Microcontroller: architecture and programming, concept of embedded processor, Real time operating system and Internet of things.	
1	**Introduction:** Overview, comparison with general computing systems, processors, hardware components and software, design process, classification and major application areas, skills required for system designer.	06
2	**RISC Processor (ARM7):** The RISC design philosophy, features and architecture, processor modes, register organization, exception and its handling, addressing modes, ARM and Thumb instruction, co-processor interface, assembly language programming, ARM7 processor families.	10
3	**DSP Processor:** TMS320C67XX 32 bit floating point DSP Processor: introduction, features and architecture, applications, addressing modes, memory architecture, external memory accesses, pipeline operation, hardware tools, and software tools: code composer studio.	10

4	**OS Based Embedded System Design and RTOS:** Introduction to OS its structure, characteristics of RTOS, tasks states, Semaphores, message queue, scheduling task operations, inter-process communication, memory and file I/O management, performance matrix and interrupt handling security issue in RTOS, RT Linux architecture and internals, programming and configuration.	08
5	**Internet of things (IOT) and its applications:** Introduction, layered architecture, functional view, enabling technologies for IOT, technology in networking, processes, data management and security, application areas, Future of IOT.	08
6	**Case Studies:** IOT based smart City and health monitoring system, adaptive cruise control car, RFID based smart cards, ARM based digital signage, smart phone, applications of embedded system in instrumentation.	06

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Raj Kamal, "Embedded system Architecture, Programming and Design", Second Edition, Tata McGraw Hill, 2008.
2. Andrew N.Sloss, "ARM Systems Developer's Guides- Designing & Optimizing System Software ", Dominic Symes, Chris Wright, 2008, Elsevier.
3. Lapsley P.,Bier, Shoham A, "DSP Processor Fundamentals: Architectures And Features", S,Chand& Co. ,New Delhi ,1997.
4. Dr. OvidiuVermesan, Dr Peter Friess, "Internet of Things: From research and Innovation to Market Development", River Publisher, 2014.
5. Jimmy Schaeffler, "Digital Signage: Software, Networks, Advertising, and Displays: A Primer for Understanding the Business", Focal press U.K., 2008,
6. ShibuK.V ,"Introduction to Embedded Systems", McGraw Hill, 2009.
7. Frank Vahid, Tony Givargis, "Embedded System Design- A unified Hardware/Software Introduction", John Wiley, 2002.
8. Lyla,"Embedded Systems", Pearson, 2013.
9. David E. Simon,"An Embedded Software Primer", Pearson Education, 2000.
10. Jonathan W. Valvano, "Embedded Microcomputer Systems: Real Time Interfacing", 1999, Thomas Learning.
11. Qing Li, "Real Time Concepts for Embedded Systems", Elsevier, 2011.

12. Dr. Craig Hollabaugh,"Embedded Linux: Hardware, Software and Interfacing", Addition-Wesley, 2002.
13. Raspberry Pi Foundation, Documentation ‘http://www.raspberrypi.org/documentation”.

Subject Code	Subject Name	Credits
ISDLO1013	ADVANCED DIGITAL SIGNAL PROCESSING	04

Course Objectives:

- To teach design, implementation, analysis and comparison of digital filters for processing of discrete time signals.
- To explain concepts of multi-rate signal processing
- To train for application of multi-rate signal processing
- To familiarize with design of adaptive filters and homographic signal processing
- To teach the fundamentals of digital signal processing in time-frequency domain& its application

Course Outcomes:

- Able to determine the frequency response of FIR and IIR filters.
- Demonstrate the multi-rate signal processing and its applications for filter bank.
- Expand the knowledge of adaptive filters and homographic signal processing.
- Ability to apply the concept of time frequency analysis.

Module	Detailed content	Hours
	Prerequisite: Signals and Systems, Unit impulse and unit step functions, Laplace Transform& its properties, Fourier Transform & its properties, Z-Transform & its properties, Convolution and Correlation of signals.	
1	**Discrete Fourier Transform:** Introduction to DTFT, Fourier representation of finite duration sequences, the Discrete Fourier Transform, properties of the DFT, Linear convolution using the DFT and IDFT. Computation of the Discrete Fourier Transform: - Decimation in frequency (DIF) algorithms, Decimation in time (DIT) algorithms for Radix 2, 3 composite.	08
2	**Multirate Signal Processing & Filter Banks:** Introduction, Decimation, Interpolation, Fractional rate conversion, Multistage Filter implementation. Interpolated FIR filter (IFIR), IFIR technique for decimation filter and interpolation filter, analysis and Synthesis banks. Poly phase structures – Polyphase structure for decimation and interpolation filters.	10
3	**Applications of Multirate Signal Processing:** Filter banks, digital audio, analog voice privacy system, transmultiplexers, Multirate adaptive filters, Sub band coding – spectral analysis, amplitude and phase analysis, simple and M channel QMF.	10
4	**Adaptive Filtering:** Principles of adaptive filtering, LMS and RLS algorithms, Performance of LMS, LMS with Gaussian regressors, Applications in noise and echo cancellation, Weighted Energy Conservation.	08

5	**Homographic Signal Processing:** Homograph systems for convolution, Properties of complex spectrum, Application of homographic deconvolution.	06
6	**Applications:** Speech processing application, Digital processing of audio signals, DSP based biomedical signals measurement systems, Homomorphic vocoder.	06

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. P.P. Vaidhyanathan, “Multirate systems and filter banks”, Prentice Hall, 1993
2. Peter O’Shea, Amin Z. Sadik, Zahir M. Hussain, “Digital Signal Processing”, Springer Berlin Heidelberg, 2011.
3. Paulo S. R. Diniz, “Adaptive Filtering”, Springer US, 2013.
4. Emmanuel Ifeachor and Barrie Jervis, “Digital Signal Processing: A Practical Approach”, (2nd Edition), Prentice Hall, 2004.
5. J.G Proakis and D.G Manolakis , "Digital Signal Processing: Principles, Algorithms and Applications", PHI, 2004.
6. A.V. Oppehein and R.W. Schafer, “Discrete time signal processing”, PHI, 1992.
7. Haykins,” Adaptive Filter Theory”, Prentice Hall, 1986.
8. Leon Cohen, “Time Frequency analysis”, Prentice Hall, 1995.
9. Orfanidis Sophocles J, “Optimum Signal Processing”, McGraw Hill, 1988.

Subject Code	Subject Name	Credits
ISDLO1014	INSTRUMENTATION FOR NON-CONVENTIONAL ENERGY SOURCES	04

Course Objectives:

- To create awareness of energy resources and its scenario in India.
- To build up the importance of the natural non-conventional energy sources like solar, wind, tidal, ocean etc.
- To make them understand the instrumentation involved for the better utilization of energy sources with environmental balance.

Course Outcomes:

- Ability to understand environmental science, effects and natural energy sources.
- Develop an approach towards conservation and utilization of natural energy sources.
- Able to analyze problems in energy conservation and applications of instrumentation as an effective tool.
- Ability to understand importance of biogas, wind power, tidal power and their use as an energy source.

Module	Detailed content	Hours
	Prerequisite: Indian and global energy sources, conventional and non-conventional energy sources, Importance of natural energy conservation and management.	
1	**Solar photovoltaic system:** Photovoltaic effect, Efficiency of solar cells, Semiconductor materials for, solar cells, Solar photovoltaic system and its instrumentation, Standards of solar photovoltaic system, Applications of PV system, PV hybrid system.	06
2	**Biogas:** Photosynthesis, Bio gas production Aerobic and anaerobic bio-conversion process, Raw materials, Properties of bio gas, Producer gas, Transportation of bio gas, bio gas plant technology & status, Community biogas plants, Problems involved in bio gas production, Bio gas process instrumentation and applications, Biomass conversion techniques, Biomass gasification, Energy recovery from urban waste, Power generation from liquid waste, Biomass cogeneration, Energy plantation.	10
3	**Wind energy:** Properties of wind, Availability of wind energy in India, wind velocity, Wind machine fundamentals, Types of wind machines and their characteristics, Horizontal and Vertical axis wind mills, Elementary design principles, Coefficient of performance of a wind mill rotor, Aerodynamic considerations in wind mill design, Selection of a wind mill, Wind energy farms, Recent development.	10
4	**Tidal power:** Tides and waves as sources of energy, Fundamentals of tidal power, Use of tidal energy, Limitations of tidal energy conversion systems.	06
5	**Geothermal energy:** Structure of earth's interior, geothermal sites,	08

	earthquakes & volcanoes, Geothermal resources, Principal of working, Types of geothermal station with schematic representation, Problems associated with geothermal conversion.	
6	**Ocean energy:** Principle of ocean thermal energy conversion, Wave energy conversion machines, Power plants based on ocean energy, Problems associated with ocean thermal energy conversion systems, Thermoelectric OTEC, Developments of OTEC	08

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Bansal Keemann, Meliss, "Renewable energy sources and conversion technology", Tata McGraw Hill, 1990.
2. Kothari D.P., "Renewable energy resources and emerging technologies", Prentice Hall of India Pvt. Ltd.
3. Ashok V. Desai, "Nonconventional Energy", New Age International Publishers Ltd.
4. P.K. Nag, "Power Plant Engineering", Tata McGraw Hill, 2001.
5. R. K. Jain, "Mechanical and Industrial Measurements", Khanna Publishers, New Delhi, 1995.
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7. R.K. Rajput , "Non-Conventional Energy Sources and Utilisation", S.Chand Publication, 2012.
8. G.D. Rai, "Non-conventional Energy Sources", Khanna Publication, 2004.
9. Sukhatme, "Solar Energy: Principles of Thermal Collection and Storage", Tata McGraw-Hill Publication, 2008.

Subject Code	Subject Name	Credits
ISDLO1015	ADVANCED ANALYTICAL INSTRUMENTATION	04

Course Objectives:

- To introduce the basic concept of qualitative and quantitative analysis of a given sample.
- To study various spectroscopic techniques and its instrumentation.
- To study the concept of separation science and its applications.
- To study the concept of industrial analytical instrumentation with application.

Course Outcomes:

- Able to get versed with the principle, construction and working of various analytical instruments.
- Demonstrate the applications of analytical techniques in medicine, industry, air monitoring etc.
- Expose to air pollution monitoring and measurement.
- Ability to motivate them with various methods of spectroscopy and its application.

Module	Detailed content	Hours
	Prerequisite: Introduction to chemical analysis, Classical and Instrumental methods, Classification of Instrumental techniques, Important considerations in evaluating an instrumental method.	
1	**Spectrophotometric /Gas Analysers:** IR/NIR/UV/VIS Analysers, Cells, Detectors, Signal Processing, Calibration, Minimization of Interference and Comparative Analysis of Analysers & Gaseous components detected Hydrocarbon Analysers, Flame Ionisation Detectors, Principle of Operation, Oxygen and NO/NO2 Analysers, Signal Processing, Calibration, Minimization of Interference, Applications, Sampling Systems, Desirable Features, Filters, Flow and Pressure regulators, Coolers, Condensers, Vacuum Pumps, Blowback Cleaning System, Exhaust Practices.	10
2	**Compositional Process Analyser:** Gas and Liquid Chromatography, Columns, Gas and liquid detectors, Data processing, Process chromatograph, calibration and application, Mass Spectrometry components, Different types of Sampling systems, Calibration and applications.	08
3	**Environmental Pollution Monitoring Instruments:** Air pollution monitoring instruments: Representation of gas concentrations, Types and concentration of various gas pollutants, Instrumental Technique and measurement range. Carbon Monoxide: Non-dispersive Infrared analyzer, Gas chromatography, Sulphur Dioxide: Colorimetric, Conductivity meter, Gas Chromatography, Coulometry, Flame photometric detector, Ultraviolet fluorescence method.	08
4	**Nuclear Magnetic Resonance Spectroscopy:** Principle of operation, components, sensitivity enhancement techniques and different types	06

	of NMR Spectrometers with applications.	
5	**Radiochemical Instruments and Nuclear Pulse Spectroscopy:** Radiation detectors, Principle of operation, Constructional details, Calibration and applications, Nuclear Spectroscopy, Instrumentation techniques, Signal processing and electronics of nuclear spectroscopy, Pulse height analyser and various nuclear detectors.	08
6	**Process Analytical Instrumentation in Industry:** In-process Sampling, In-process Analysis: Flow injection analysis, Spectroscopic analysis, Separation Analysis, Imaging Analysis, Electrochemical Analysis, Laboratory Integrated Management System.	08

Assessment:

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End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. B. G. Liptak, "Instrument Engineers' Handbook: Process Measurement and Analysis", Butterworth Hieneman, Boston, 1995.
2. D.M. Considine, "Process Instruments and Control Handbook", 4th edition, McGraw Hill New York, 1993.
3. K. J. Clevett, "Process Analyser Technology", John Wiley & Sons, New York,1986.
4. G. K. Macmillan, "pH Measurement and Control", ISA 1994.
5. pH and Conductivity – Book 13 Fisher Rosemount Educational Services.
6. R.E. Sherman, "Analytical Instrumentation", TWI Press, Indiana, 1996.
7. Gillian McMahon "Analytical Instrumentation: A Guide to Laboratory, Portable and miniaturized Instruments", John Wiley and sons, 2007.
8. Willard, Merritt, Dean and Settle, "Instrumental Methods of Analysis", 7th edition, (CBS publishers, New Delhi) 2001.
9. Galen W. Ewing, "Instrumental Methods of Chemical Analysis", 5th edition, (McGraw-Hill Book Company), 1985.

Subject Code	Subject Name	Credits
ISDLO1016	FAULT TOLERANT CONTROL	04

Course Objectives:

- To familiarize concept of fault detection and isolation of industrial processes and systems, additionally to fault tolerant control with a special emphasis to model based techniques.
- To explain the basic concept of fault detection systems.
- To facilitate the concept of fault diagnosis systems.

Course Outcomes:

- Ability to design fault tolerant controllers for given processes.
- Ability to select appropriate fault detection method for the given system.
- Ability to implement fault-tolerant control systems for a simple industrial process.

Module	Detailed content	Hours
	Prerequisite: Review of Faults, Diagnosis, approaches, structures, estimators. Concept of its control.	
1	**Introduction:** Types of faults and different tasks of Fault Diagnosis and Implementation - Different approaches to FDD: Model free and Model based approaches.	06
2	**Analytical Redundancy Concepts:** Mathematical representation of Faults and Disturbances: Additive and Multiplicative types – Residual Generation: Detection, Isolation, Computational and stability properties – Design of Residual generator – Residual specification and Implementation.	08
3	**Design of Structured Residuals & Directional Structured Residuals:** Introduction- Residual structure of single fault Isolation: Structural and Canonical structures- Residual structure of multiple fault Isolation: Diagonal and Full Row canonical concepts – Introduction to parity equation implementation and alternative representation - Directional Specifications: Directional specification with and without disturbances – Parity Equation Implementation.	10
4	**Fault Diagnosis Using State Estimators:** Introduction – State Observer – State Estimators – Norms based residual evaluation and threshold computation -Statistical methods based residual evaluation and threshold settings: Generalized Likelihood Ratio Approach – Marginalized Likelihood Ratio Approach.	08
5	**Fault Tolerant Control:** Introduction – Passive Fault-tolerant Control- Active Fault tolerant Control – Actuator and Sensor Fault tolerance Principles: - Compensation for actuator – Sensor Fault tolerant Control Design – Fault-tolerant Control Architecture - Fault-tolerant control design against major actuator failures.	08
6	**Case Studies:** Fault tolerant Control of Three-tank System – Diagnosis and Fault-tolerant control of chemical process –	08

	supervision of steam generator – Different types of faults in Control valves – Automatic detection, quantification and compensation of valve stiction.	

Assessment:

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End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Steven X. Ding, "Model based Fault Diagnosis Techniques: Schemes, Algorithms, and Tools", Springer Publication, 2008.
2. Rolf Isermann, "Fault-Diagnosis Systems an Introduction from Fault Detection to Fault Tolerance", Springer Verlag, 2006.
3. Hassan Noura, Didier Theilliol, Jean-Christophe Ponsart, Abbas Chamseddine, "Fault-Tolerant Control Systems: Design and Practical Applications", Springer Publication, 2009.
4. Mogens Blanke, "Diagnosis and Fault-Tolerant Control", Springer, 2003.
5. Ali AhammadShoukatChoudhury, Sirish L. Shah, Nina F. Thornhill, "Diagnosis of Process Nonlinearities and Valve Stiction: Data Driven Approaches", Springer, 2008.
6. Janos J. Gertler, "Fault Detection and Diagnosis in Engineering systems" 2nd Edition, 1998.

Subject Code	Subject Name	Credits
ILO1011	PRODUCT LIFE CYCLE MANAGEMENT	03

Objectives:

1. To familiarize the students with the need, benefits and components of PLM
2. To acquaint students with Product Data Management & PLM strategies
3. To give insights into new product development program and guidelines for designing and developing a product
4. To familiarize the students with Virtual Product Development

Outcomes: Learner will be able to…

1. Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.
2. Illustrate various approaches and techniques for designing and developing products.
3. Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc.
4. Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant

Module	Detailed Contents	Hrs
01	**Introduction to Product Lifecycle Management (PLM):**Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications **PLM Strategies:** Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy , Change management for PLM	12
02	**Product Design:** Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Properties and Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process	09
03	**Product Data Management (PDM):**Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation	06
04	**Virtual Product Development Tools:** For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies	06

05	**Integration of Environmental Aspects in Product Design:** Sustainable Development, Design for Environment, Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design	06
06	**Life Cycle Assessment and Life Cycle Cost Analysis:** Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis	06

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. 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)
4. Only Four question need to be solved.

REFERENCES:

1. John Stark, "Product Lifecycle Management: Paradigm for 21st Century Product Realisation", Springer-Verlag, 2004. ISBN: 1852338105
2. Fabio Giudice, Guido La Rosa, Antonino Risitano, "Product Design for the environment-A life cycle approach", Taylor & Francis 2006, ISBN: 0849327229
3. Saaksvuori Antti, Immonen Anselmie, "Product Life Cycle Management", Springer, Dreamtech, ISBN: 3540257314
4. Michael Grieve, "Product Lifecycle Management: Driving the next generation of lean thinking", Tata McGraw Hill, 2006, ISBN: 0070636265

Subject Code	Subject Name	Credits
ILO1012	RELIABILITY ENGINEERING	03

Objectives:

- To familiarize the students with various aspects of probability theory
- To acquaint the students with reliability and its concepts
- To introduce the students to methods of estimating the system reliability of simple and complex systems
- To understand the various aspects of Maintainability, Availability and FMEA procedure

Outcomes: Learner will be able to…

- Understand and apply the concept of Probability to engineering problems
- Apply various reliability concepts to calculate different reliability parameters
- Estimate the system reliability of simple and complex systems
- Carry out a Failure Mode Effect and Criticality Analysis

Module	Detailed Contents	Hrs
01	**Probability theory:** Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem. **Probability Distributions:** Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance. **Measures of Dispersion:** Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness and Kurtosis.	10
02	**Reliability Concepts:** Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve. **Failure Data Analysis:** Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions. **Reliability Hazard Models:** Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution functions and reliability analysis.	10
03	**System Reliability:** System Configurations: Series, parallel, mixed configuration, k out of n structure, Complex systems.	05
04	**Reliability Improvement:** Redundancy Techniques: Element redundancy, Unit redundancy, Standby redundancies. Markov analysis. System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method.	10
05	**Maintainability and Availability:** System downtime, Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability – qualitative aspects.	05
06	**Failure Mode, Effects and Criticality Analysis:** Failure mode effects analysis, severity/criticality analysis, FMECA examples. Fault tree construction, basic symbols, development of functional reliability block diagram, Fau1t tree analysis and Event tree Analysis	05

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. 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)
4. Only Four question need to be solved.

REFERENCES:

1. L.S. Srinath, "Reliability Engineering", Affiliated East-Wast Press (P) Ltd., 1985.
2. Charles E. Ebeling, "Reliability and Maintainability Engineering", Tata McGraw Hill.
3. B.S. Dhillion, C. Singh, "Engineering Reliability", John Wiley & Sons, 1980.
4. P.D.T. Conor, "Practical Reliability Engg.", John Wiley & Sons, 1985.
5. K.C. Kapur, L.R. Lamberson, "Reliability in Engineering Design", John Wiley & Sons.
6. Murray R. Spiegel, "Probability and Statistics", Tata McGraw-Hill Publishing Co. Ltd.

Subject Code	Subject Name	Credits
ILO1013	MANAGEMENT INFORMATION SYSTEM	03

Objectives:

- The course is blend of Management and Technical field.
- Discuss the roles played by information technology in today's business and define various technology architectures on which information systems are built
- Define and analyze typical functional information systems and identify how they meet the needs of the firm to deliver efficiency and competitive advantage
- Identify the basic steps in systems development
- Define and analyze various MIS management responsibilities, including planning, budgeting, project management, and personnel management
- Discuss critical ethical and social issues in information systems

Outcomes: Learner will be able to…

- Explain how information systems Transform Business
- Identify the impact information systems have on an organization
- Describe IT infrastructure and its components and its current trends
- Understand the principal tools and technologies for accessing information from databases to improve business performance and decision making
- Identify the types of systems used for enterprise-wide knowledge management and how they provide value for businesses

Module	Detailed Contents	Hrs
01	**Introduction To Information Systems (IS):** Computer Based Information Systems, Impact of IT on organizations, Importance of IS to Society. Organizational Strategy, Competitive Advantages and IS.	7
02	**Data and Knowledge Management:** Database Approach, Big Data, Data warehouse and Data Marts, Knowledge Management. Business intelligence (BI): Managers and Decision Making, BI for Data analysis and Presenting Results	9
03	**Ethical issues and Privacy:** Information Security. Threat to IS, and Security Controls	6
04	**Social Computing (SC):** Web 2.0 and 3.0, SC in business-shopping, Marketing, Operational and Analytic CRM, E-business and E-commerce – B2B B2C. Mobile commerce.	7
05	**Computer Networks** Wired and Wireless technology, Pervasive computing, Cloud computing model.	6
06	**Information System within Organization:** Transaction Processing Systems, Functional Area Information System, ERP and ERP support of Business Process. Acquiring Information Systems and Applications: Various System development life cycle models.	10

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. 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)
4. Only Four question need to be solved.

REFERENCES:

1. Management Information Systems: Kelly Rainer, Brad Prince by Wiley
2. Management Information Systems: Managing the Digital Firm (10th Edition). K.C. Laudon and J.P. Laudon, Prentice Hall, 2007.
3. Managing Information Systems: Strategy and Organization, D. Boddy, A. Boonstra, Prentice Hall, 2008

Subject Code	Subject Name	Credits
ILO1014	DESIGN OF EXPERIMENTS	03

Objectives:

- To understand the issues and principles of Design of Experiments (DOE).
- To list the guidelines for designing experiments.
- To become familiar with methodologies that can be used in conjunction with experimental designs for robustness and optimization

Outcomes: Learner will be able to…

- Plan data collection, to turn data into information and to make decisions that lead to appropriate action.
- Apply the methods taught to real life situations.
- Plan, analyze, and interpret the results of experiments

Module	Detailed Contents	Hrs
01	**Introduction:** Strategy of Experimentation, Typical Applications of Experimental Design, Guidelines for Designing Experiments, Response Surface Methodology.	06
02	**Fitting Regression Models:** Linear Regression Models, Estimation of the Parameters in Linear Regression Models, Hypothesis Testing in Multiple Regression, Confidence Intervals in Multiple Regression, Prediction of new response observation, Regression model diagnostics, Testing for lack of fit.	08
03	**Two-Level Factorial Designs:** The 2^2Design, The 2^3 Design, The General 2^k Design, A Single Replicate of the 2^kDesign, The Addition of Center Points to the 2^kDesign, Blocking in the 2^kFactorial Design, Split-Plot Designs.	07
04	**Two-Level Fractional Factorial Designs:** The One-Half Fraction of the 2^k Design, The One-Quarter Fraction of the 2^k Design, The General 2^{k-p} Fractional Factorial Design, Resolution III Designs, Resolution IV and V Designs, Fractional Factorial Split-Plot Designs.	07
05	**Conducting Tests:** Testing Logistics, Statistical aspects of conducting tests, Characteristics of good and bad data sets, Example experiments, Attribute Vs Variable data sets.	07
06	**Taguchi Approach:** Crossed Array Designs and Signal-to-Noise Ratios, Analysis Methods, Robust design examples.	04

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered

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

1. Question paper will comprise of total six question
2. All question carry equal marks
3. 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)
4. Only Four question need to be solved.

REFERENCES:

1. Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization using Designed Experiment, 3rd edition, John Wiley & Sons, New York, 2001
2. D.C. Montgomery, Design and Analysis of Experiments, 5th edition, John Wiley & Sons, New York, 2001
3. George E P Box, J Stuart Hunter, William G Hunter, Statics for Experimenters: Design, Innovation and Discovery, 2nd Ed. Wiley
4. W J Dimond, Peactical Experiment Designs for Engineers and Scintists, John Wiley and Sons Inc. ISBN: 0-471-39054-2
5. Design and Analysis of Experiments (Springer text in Statistics), Springer by A.M. Dean, and D. T.Voss
6. Philip J Ross, "Taguchi Technique for Quality Engineering," McGraw Hill.
7. Madhav S Phadake, "Quality Engineering using Robust Design," Prentice Hall.

Subject Code	Subject Name	Credits
ILO1015	OPERATIONS RESEARCH	03

Objectives:

- Formulate a real-world problem as a mathematical programming model.
- Understand the mathematical tools that are needed to solve optimization problems.
- Use mathematical software to solve the proposed models.

Outcomes: Learner will be able to…

- Understand the theoretical workings of the simplex method for linear programming and perform iterations of it by hand.
- Understand the relationship between a linear program and its dual, including strong duality and complementary slackness.
- Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.
- Solve specialized linear programming problems like the transportation and assignment problems.
- Solve network models like the shortest path, minimum spanning tree, and maximum flow problems.
- Understand the applications of, basic methods for, and challenges in integer programming
- Model a dynamic system as a queuing model and compute important performance measures

Module	Detailed Contents	Hrs
01	**Introduction to Operations Research***:* Introduction, Historical Background, Scope of Operations Research , Features of Operations Research, Phases of Operations Research, Types of Operations Research Models, Operations Research Methodology, Operations Research Techniques and Tools , Structure of the Mathematical Model, Limitations of Operations Research	02
02	**Linear Programming***:* Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, *Simplex Method* Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method, ***Duality****,* Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis	06
03	**Transportation Problem***:* Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method. **Assignment Problem***:* Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem, Travelling Salesman Problem	06
04	**Integer Programming Problem***:* Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms.	06

05	**Queuing models**: queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population	06
06	**Simulation***:* Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation *Monte-Carlo Method:* Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation	04
07	**Dynamic programming**. Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.	04
08	**Games Theory**. Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.	04
09	**Inventory Models**: Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model,	04

Assessment:

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End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. 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)
4. Only Four question need to be solved.

REFERENCES:

1. Taha, H.A. "Operations Research - An Introduction", Prentice Hall, (7th Edition), 2002.
2. Ravindran, A, Phillips, D. T and Solberg, J. J. "Operations Research: Principles and Practice", John Willey and Sons, 2nd Edition, 2009.

3. Hiller, F. S. and Liebermann, G. J. "Introduction to Operations Research", Tata McGraw Hill, 2002.
4. Operations Research, S. D. Sharma, KedarNath Ram Nath-Meerut.
5. Operations Research, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.

Subject Code	Subject Name	Credits
ILO1016	CYBER SECURITY AND LAWS	03

Objectives:

- To understand and identify different types cyber crime and cyber law
- To recognized Indian IT Act 2008 and its latest amendments
- To learn various types of security standards compliances

Outcomes: Learner will be able to…

- Understand the concept of cyber crime and its effect on outside world
- Interpret and apply IT law in various legal issues
- Distinguish different aspects of cyber law
- Apply Information Security Standards compliance during software design and development

Module	Detailed Contents	Hrs
01	**Introduction to Cybercrime:** Cybercrime definition and origins of the world, Cybercrime and information security, Classifications of cybercrime, Cybercrime and the Indian ITA 2000, A global Perspective on cybercrimes.	4
02	**Cyber offenses & Cybercrime:** How criminal plan the attacks, Social Engg, Cyber stalking, Cybercafé and Cybercrimes, Botnets, Attack vector, Cloud computing, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile, Devices-Related Security Issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops	10
03	**Tools and Methods Used in Cyberline:** Phishing, Password Cracking, Key loggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft)	6
04	**The Concept of Cyberspace :** E-Commerce , The Contract Aspects in Cyber Law ,The Security Aspect of Cyber Law ,The Intellectual Property Aspect in Cyber Law , The Evidence Aspect in Cyber Law , The Criminal Aspect in Cyber Law, Global Trends in Cyber Law , Legal Framework for Electronic Data Interchange Law Relating to Electronic Banking , The Need for an Indian Cyber Law	8
05	**Indian IT Act.:** Cyber Crime and Criminal Justice : Penalties, Adjudication and Appeals Under the IT Act, 2000,IT Act. 2008 and its Amendments	8
06	**Information Security Standard compliances:** SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI.	6

Assessment:

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2. All question carry equal marks
3. 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)
4. Only Four question need to be solved.

REFERENCES:

1. Nina Godbole, Sunit Belapure, *Cyber Security*, Wiley India, New Delhi
2. The Indian Cyber Law by Suresh T. Vishwanathan; Bharat Law House New Delhi
3. The Information technology Act, 2000; Bare Act- Professional Book Publishers, New Delhi.
4. Cyber Law & Cyber Crimes By Advocate Prashant Mali; Snow White Publications, Mumbai
5. Nina Godbole, *Information Systems Security*, Wiley India, New Delhi
6. Kennetch J. Knapp, *Cyber Security* &*Global Information Assurance* Information Science Publishing.
7. William Stallings, *Cryptography and Network Security*, Pearson Publication
8. Websites for more information is available on : The Information Technology ACT, 2008- TIFR : https://www.tifrh.res.in
9. Website for more information , A Compliance Primer for IT professional : https://www.sans.org/reading-room/whitepapers/compliance/compliance-primer-professionals-33538

Subject Code	Subject Name	Credits
ILO1017	Disaster Management and Mitigation Measures	03

Objectives:

- To understand the various types of disaster occurring around the world
- To identify extent and damaging capacity of a disaster
- To study and understand the means of losses and methods to overcome /minimize it.
- To understand role of individual and various organization during and after disaster
- To know warning systems, their implementation and based on this to initiate training to a laymen
- To understand application of GIS in the field of disaster management
- To understand the emergency government response structures before, during and after disaster

Outcomes: Learner will be able to…

- Understand natural as well as manmade disaster and their extent and possible effects on the economy.
- Planning of national importance structures based upon the previous history.
- Understand government policies, acts and various organizational structure associated with an emergency.
- Know the simple do's and don'ts in such extreme events and act accordingly.

Module	Detailed Contents	Hrs
01	**Introduction:** Definition of Disaster, hazard, global and Indian scenario, general perspective, importance of study in human life, Direct and indirect effects of disasters, long term effects of disasters. Introduction to global warming and climate change.	03
02	**Natural Disaster and Manmade disasters**: Natural Disaster: Meaning and nature of natural disaster, Flood, Flash flood, drought, cloud burst, Earthquake, Landslides, Avalanches, Volcanic eruptions, Mudflow, Cyclone, Storm, Storm Surge, climate change, global warming, sea level rise, ozone depletion . Manmade Disasters: Chemical, Industrial, Nuclear and Fire Hazards. Role of growing population and subsequent industrialization, urbanization and changing lifestyle of human beings in frequent occurrences of manmade disasters.	06
03	**Disaster Management, Policy and Administration:** Disaster management: meaning, concept, importance, objective of disaster management policy, disaster risks in India, Paradigm shift in disaster management. Policy and administration: Importance and principles of disaster management policies, command and co-ordination of in disaster management, rescue operations-how to start with and how to proceed in due course of time, study of flowchart showing the entire process.	06
04	**Institutional Framework for Disaster Management in India:** Importance of public awareness, Preparation and execution of emergency management programme. Scope and responsibilities of National Institute of Disaster Management (NIDM) and National disaster management authority (NDMA) in India. Methods and measures to avoid disasters, Management of casualties, set	06

	up of emergency facilities, importance of effective communication amongst different agencies in such situations. Use of Internet and softwares for effective disaster management. Applications of GIS, Remote sensing and GPS in this regard.	
05	**Financing Relief Measures**: Ways to raise finance for relief expenditure, role of government agencies and NGO's in this process, Legal aspects related to finance raising as well as overall management of disasters. Various NGO's and the works they have carried out in the past on the occurrence of various disasters, Ways to approach these teams. International relief aid agencies and their role in extreme events.	09
05	**Preventive and Mitigation Measures**: Pre-disaster, during disaster and post-disaster measures in some events in general, Structural mapping: Risk mapping, assessment and analysis, sea walls and embankments, Bio shield, shelters, early warning and communication. Non Structural Mitigation: Community based disaster preparedness, risk transfer and risk financing, capacity development and training, awareness and education, contingency plans. Do's and don'ts in case of disasters and effective implementation of relief aids.	06

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4. Only Four question need to be solved.

REFERENCES:

1. 'Disaster Management' by Harsh K.Gupta, Universities Press Publications.
2. 'Disaster Management: An Appraisal of Institutional Mechanisms in India' by O.S.Dagur, published by Centre for land warfare studies, New Delhi, 2011.
3. 'Introduction to International Disaster Management' by Damon Copolla, Butterworth Heinemann Elseveir Publications.
4. 'Disaster Management Handbook' by Jack Pinkowski, CRC Press Taylor and Francis group.
5. 'Disaster management & rehabilitation' by RajdeepDasgupta, Mittal Publications, New Delhi.

6. ‘Natural Hazards and Disaster Management, Vulnerability and Mitigation – R B Singh, Rawat Publications
7. Concepts and Techniques of GIS –C.P.Lo Albert, K.W. Yonng – Prentice Hall (India) Publications.

(Learners are expected to refer reports published at national and International level and updated information available on authentic web sites)

Subject Code	Subject Name	Credits
ILO1018	ENERGY AUDIT AND MANAGEMENT	03

Objectives:

- To understand the importance energy security for sustainable development and the fundamentals of energy conservation.
- To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management
- To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

Outcomes: Learner will be able to…

- To identify and describe present state of energy security and its importance.
- To identify and describe the basic principles and methodologies adopted in energy audit of an utility.
- To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities.
- To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities
- To analyze the data collected during performance evaluation and recommend energy saving measures

Module	Detailed Contents	Hrs
01	**Energy Scenario:** Present Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy Security, Energy Conservation and its Importance, Energy Conservation Act-2001 and its Features. Basics of Energy and its various forms, Material and Energy balance	04
02	**Energy Audit Principles:** Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution. Elements of monitoring& targeting; Energy audit Instruments; Data and information-analysis. Financial analysis techniques: Simple payback period, NPV, Return on investment (ROI), Internal rate of return (IRR)	08
03	**Energy Management and Energy Conservation in Electrical System:** Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipments and appliances, star ratings. **Energy efficiency measures in lighting system, Lighting control:** Occupancy sensors, daylight integration, and use of intelligent controllers. Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.	10

04	**Energy Management and Energy Conservation in Thermal Systems:** Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery, use of insulation- types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.	10
05	**Energy Performance Assessment:** On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method, Financial Analysis.	04
06	**Energy conservation in Buildings:** Energy Conservation Building Codes (ECBC): Green Building, LEED rating, Application of Non-Conventional and Renewable Energy Sources	03

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4. Only Four question need to be solved.

REFERENCES:

1. Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons
4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy Research Institute (TERI).
5. Energy Management Principles, C.B.Smith, Pergamon Press
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont

Press
7. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press
8. www.energymanagertraining.com
9. www.bee-india.nic.in

Subject Code	Subject Name	Credits
ISL101	LABORATORY-I	01

Courses Objectives:

- To provide adequate knowledge of mathematical computation in engineering applications.
- To attain hands-on experience on different computational tools and software.
- To improve skill of student in engineering mathematics.

Courses Outcomes:

- Ability to use the computational tools effectively.
- Ability to select the method, analysis and optimize the given problem by mathematical approach.
- Ability to define, illustrate and apply the concepts of random variables, probability distributions.
- Apply programming skills and use mathematical software as a discovery tool and to solve a real-world problem.

Expt. No.	Title
1	Computation of Eigen values, Eigen vectors, norms and their mathematical operations using standard computing tools.
2	LQ and QR decomposition methods for system performance using computational tools.
3	Gram – Schmidt orthonormalization using computational tools.
4	Write a C-program to find solution of algebraic equation using Gauss-Jordan method, Gauss-Seidal method.
5	Use computing tools to find solution of algebraic equation using Gauss elimination method, Newton-Raphson method.
6	Case study on Ritz and Kantorovich method for higher order systems.
7	Engineering application based case study on Probability.
8	Multidisciplinary application of integral transforms.

NOTE: Perform any six experiments from above list and two experiments from Department Elective Course.

Term work: Term work consists of performing 08 practical mentioned as above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners.

Subject Code	Subject Name	Credits
ISL102	LABORATORY-II	01

Course Objectives:

- To provide adequate knowledge of design and implementation of control systems.
- To provide students with hands-on experience to apply their practical knowledge in designing, testing and simulation of any instrumentation and process control system.
- To provide practical experience to the students in simulation software and real time interfacing with process control applications.

Course Outcomes:

- Ability to design signal conditioning circuit for any given sensor.
- Ability to simulate process control loop using simulation tools and software like LabVIEW / MATLAB.
- Ability to interface hardware and software tools for analysis and optimization.
- Ability to find out mathematical model of any given real time system.

Expt. No.	Title
1	Microcontroller based temperature/ strain/ vibration measurement system.
2	PC based temperature/ level/ flow/ measurement system.
3	Hardware-In- Loop (HIL) simulation of PC based data acquisition and control.
4	LabVIEW based data logger and analysis.
5	Speed and Position control of servo motor using MATLAB / Lab VIEW.
6	Modeling of simple process using system identification technique.
7	Tank level control simulation in Lab VIEW.
8	Real time testing performance of different tuning methods of PID.

NOTE: Perform any six experiments from above list and two experiments from Department Elective Course.

Term work: Term work consists of performing 08 practical mentioned as above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners.

Subject Code	Subject Name	Credits
ISC201	MODERN CONTROL THEORY	04

Course Objectives:

- To develop the skills needed to represent the system in state space form.
- To impart knowledge required to design state feedback controller and state estimator.
- To impart knowledge and skills needed to classify singular points and construct phase trajectory using delta and isocline methods.
- To make the students understand the concepts of stability and introduce techniques to assess the stability of certain class of non-linear system.
- To make the students understand the various non-linear behaviors such as Limit cycles, input multiplicity and output multiplicity.

Course Outcomes:

- Ability to represent the time-invariant systems in state space form as well as to analyze, whether the system is stabilizable, controllable, observable and detectable.
- Ability to design state feedback controller and state estimator.
- Ability to classify singular points and construct phase trajectory using delta and isocline methods.
- Ability to use the techniques such as describing function, Lyapunov Stability, Popov's Stability Criterion and Circle Criterion to assess the stability of certain class of non-linear system.
- Ability to describe non-linear behaviors such as Limit cycles, input multiplicity and output multiplicity.

Module	Detailed content	Hours
	Prerequisite: Introduction, basic materials in state space analysis, transfer matrix, State equations for dynamic systems, State equations using phase, physical and canonical variables, realization of transfer matrices, Minimal realization.	
1	**State Space Approach of continuous time systems:** Review of state model for systems, Non uniqueness of state model, Role of Eigen values and Eigen vectors, State transition matrix and its properties, free and forced responses, State Diagrams, minimal realization, balanced realization.	08
2	**Controllability and Observability:** Canonical Realizations, Duality, Decomposition of Uncontrollable and Unobservable realizations, Popov test. Effect of state feedback on controllability and observability, Design of State Feedback Control through Pole placement. Full order observer and reduced order observer	08
3	**State space analysis of discrete time systems:** Discretization of State equations for dynamic systems, State equations using phase, physical and canonical variables, realization of transfer matrices, Minimal realization, Solution of state equation, stability.	10

4	**Non-Linear Systems:** Types of Non-Linearity, Typical Examples:– Singular Points, Phase plane analysis (analytical and graphical methods), Limit cycles, Equivalent Linearization, Describing Function , Analysis, Derivation of describing functions for different non-linear elements.	06
5	**Stability of Non-Linear Systems:** Stability concepts, Equilibrium points, BIBO and Asymptotic stability, Stability Analysis by DF method, Lyapunov Stability Criteria, Krasovskil's method, Variable Gradient Method, Popov's Stability Criterion, Circle Criterion.	08
6	**Non Linear Control Analysis:** Mathematical preliminaries from point set toplogy, Euler-Lagrange equations of motion, Equilibrium points, Linearization, State-space formulation, Second-order systems, Phase-portrait, Limit cycle, Lyapunov stability**.**	08

Assessment:

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End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. M. Gopal, "Modern Control System Theory",New Age International Publishers, 2nd edition, 1996
2. D.E.Kirk, "Optimal Control Theory", Prentice-Hall. 1970.
3. M. Vidyasagar, "Nonlinear Systems Analysis". 2nd Edition.Prentice Hall, 1993.
4. K. Ogata "Modern Control Engineering", Prentice Hall of India, 3rd edition, 1998
5. I.J. Nagarath and M.Gopal"Control Systems Engineering", , New Age International (P)
6. M. Gopal,"Control and State Variable Methods", Tata McGraw-Hill Companies, 1997.
7. "Systems and Control" by Stainslaw H. Zak , Oxford Press, 2003
8. K.Ogata, "Modern Control Engineering", Prentice Hall, Fifth Edition, 2012.
9. M.Gopal, "Digital Control and State Variable Methods: Conventional and Intelligent Control Systems", Third Edition, Tata Mc-Graw Hill, 2009.
10. Ogata, K., "Discrete-Time Control Systems", 2/e, Prentice Hall of India.
11. Datta, B.N., "Numerical Methods for Linear Control Systems", Elsevier, 2004.
12. Chen C. T., "Linear Systems: Theory & Design". Oxford University Press New York, 1999.
13. Goodwin, Graebe S F & Salgado M E, "Control System Design", Prentice hall of India, Delhi.2002.
14. M.Gopal, "Digital Control and State Variable Method", Tata-McGrow Hill, Delhi,1998.

Subject Code	Subject Name	Credits
ISC202	APPLIED INSTRUMENTATION FOR PROCESS INDUSTRIES	04

Course Objectives:

- To educate students with instrumentation involved in all the industrial processes.
- To familiarize the students with the various unit operations and be able to apply control schemes to these processes to get the output with desired specifications.
- To expose students with hazards in industry and designing of safe plant.

Course Outcomes:

- Able to build complete strategies for process control application.
- Ability to get acquainted with all the industrial processes and demonstrate their knowledge in designing the control loops for these processes.
- Able to inculcate the safety related terms such as classification of hazards in the industry and design hazard free plant.

Module	Detailed content	Hours
	Prerequisite: Early Instrument Development, Instrumentation today, Preparing for now, Looking to the future.	
1	**Introduction:** Industry and Instrumentation: Developments and Trends, classifications and use of Instruments Control of Process. Control defined, Response of detecting element, Measuring Method, Controllers, Final control Element, Other Element, Indicators, Recorders, Transducers or Convertors, Alarm and shutdown functions.	04
2	**Petroleum Industry:** The petroleum industry and instrumentation, Topping unit instrumentation, Off-site instrumentation. **Iron- and Steel-Industry:** Overview of instrumentation in the iron·-and steelmaking process, Blast furnace instrumentation, Continuous casting equipment instrumentation, Instrumentation for an electrolytic galvanizing line.	10
3	**Waterworks Instrumentation Applications:** Overview of waterworks facilities, Water treatment-related detectors, Filtration equipment instrumentation, Chemical injection equipment instrumentation, Instrumentation for water-supply and distribution facilities, An integrated control system for large-scale, wide-area waterworks facilities, Water distribution information management system, Wastewater treatment instrumentation.	10
4	**Food Processing Industry:** Overview Food Processing Industry, Whiskey distillery instrumentation, Sugar refinery instrumentation. **Paper Manufacturing Industry:** Overview of an integrated paper mill, Pulp plant instrumentation, Instrumentation applied to the papermaking process.	10
5	**Automobile Industry:** Overview of automobile industry instrumentation, Production management at a painting factory, Storage	10

	control. **Power Industry:** Overview Power Industry, Thermal power plants, Power plant system control, Nuclear power plant overview, Pressurized water reactor control system.	
6	**Product Control in Batch Processing** Batch process recipe management, Batch process control, Recipe management and operation methods	04

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Tasuku Senbon, Futoshi Hanabuchi, "Instrumentation Systems: Fundamentals and Applications", 1st Edition, Springer-Verlag, Berlin Heidelberg GmbH, 1991.
2. William G. Andrew, H. B. Williams, "Applied Instrumentation in the Process Industries: Engineering Data and Resource Material", Volume III, Second Edition, Gulf Publishing Company, 1993.
3. Bela G. Liptak, "Instrumentation in the processing industries", 1st edition, 1973.
4. Uttam Ray Chaudhuri, "Fundamentals of Petroleum and Petrochemical Engineering", 2010.

Subject Code	Subject Name	Credits
ISC203	INDUSTRIAL AUTOMATION	04

Course Objectives:

- To brief students with origin and evolution of industrial automation.
- To train them with architecture and operation of latest automation tools like PLC, DCS, and SCADA.
- To facilitate them for designing automation system for industrial applications.
- Develop technique for preparation of various documents required for automation projects and design requirement of safe plant.

Course Outcomes:

- Ability to select suitable component for design automation system for industrial application.
- Able to design industrial plants with automation tools.
- Capable to demonstrate the application of information gained by the students for projects in their professional activities.
- Ability to use concepts of safety while designing plant and automation system.

Module	Detailed content	Hours
	Prerequisite: Fundamental of Process Control. Plant and factory automation. Traditional controller and advanced tools like-PLC, SCADA and DCS. Safety systems.	
1	**Introduction:** Fundamentals of Industrial Automation, Need and role of Automation, Evolution of Automation, Elements of process control loop, Current Trends, Automation Strategy evolution, Control system audit, Automation Tools and strategies and their location in plant.	04
2	**Programmable Logic Controller:** **PLC Hardware:** Types of Processes and Specifications. PLC Memory and Power supply calculation with redundancy consideration. Interface to Hydraulic/Pneumatic circuits. Choosing PLC for application. **PLC Programming:** Development of Relay Logic Ladder Diagram, Introduction to PLC Programming, Programming devices and languages as per IEC 61131-3 like IL, ST, FBD, CFC, SFC,PLC Timers and Counters. Advanced PLC instructions, PID Control using PLC, safety PLC.	08
3	**Distributed control system:** DCS Introduction, Location of DCS in Plant, functions, advantages and limitations, Comparison of DCS with PLC, DCS components/ block diagram, Architecture, Functional requirements at each level, Database management. Layout of DCS, Controller Details, Redundancy, I/O Card Details, Junction Box and	10

	Marshalling Cabinets, Operator Interface, Workstation Layout, different types of control panels, types of Operating Station, Programming as per IEC 61131-3, Advantages, Overview of Programming Languages, Device Signal Tags, Configuration, Programming for Live Process, Selection of DCS, DCS plant layout.	
4	**SCADA and HMI:** SCADA Concept of SCADA systems, Programming techniques for : Creation of pages, Sequencing of pages, Creating graphics & animation, Dynamos programming with variables, Trending, Historical data storage & Reporting, Alarm management, reportingof events and parameters. HMI types, Interfacing with PLC. Wireless SCADA System.	08
5	**Communication Protocols:** Open and proprietary protocol-advantages and disadvantages, wireless HART, Fieldbus-functions, hardware selection, Segment design and checking for safe and hazardous area, advantages and disadvantages, installation, documentation and economics. Wireless communication protocol.	10
6	**Design of Safe Plant:** Advanced Intrinsic safety - Entity concept, FISCO, High power trunk, Dynamic arc recognition and termination technology with advantages and disadvantages. Safety Instrumented System- Components, technologies, SIL calculation methods, SIL-calculation of PFD, RRF etc. Phases of SIS overall implementation and reliability.	08

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Terry Borden, Richard A. Cox, “Technician's Guide to Programmable Controllers”, Delmar Cengage Learning, 27-Jan-2012.
2. Bela G Liptak, “Instrument Engineer’s Handbook – Process Software and Digital Network”, CRC Press, 2005.
3. Dobrivojie Popovic, Vijay Bhatkar, “Distributed Computer Control for Industrial Automation”, CRC Press, 1990.
4. Gary A. Dunning, “Introduction to Programmable Logic Controllers”, Third Edition, 2005.
5. Luis A. Bryan, E. A. Bryan, “Programmable Controllers: Theory and Implementation”, Second Edition, American Technical Publishers, Incorporated, 2002.
6. John W. Webb, Ronald A. Reis, “Programmable Logic Controllers: Principles and Applications”, Fifth Edition, Prentice Hall, 2003.

7. Paul Gruhn, Harry L Cheddie, " Safety Instrumented System: Design, Analysis and justification", ISA, 2nd edition, 2006.
8. Ian Verhappen, Augsto Periria, "Foundation Fieldbus", ISA,2006
9. Stuart A. Boyer, "SCADA supervisory control and data acquisition", ISA Publication, 1993.
10. Jonas Berge "Fieldbuses for Process Control: Engineering, Operation, and Maintenance",ISA Publication, 2002.
11. Thomas Hughes, "Programmable Logic Controller", ISA Publication, 2005.

Subject Code	Subject Name	Credits
ISDLO2021	FRACTIONAL ORDER MODELING AND CONTROL	04

Course Objectives:

- To explain concept of fractional- order modeling and control.
- Familarize with mathematical basis of fractional calculus: Gamma function, Mittag-Leffler function, Dawson's function, Hypergeometric function, etc.
- To create awareness for designing of fractional order systems in physical world.
- To expand knowledge about design of fractional controller using different methods and tools.

Course Outcomes:

- Ability to apply the concept of fractional order systems.
- Able to inculcate Fractional Calculus and Fractional-order Differential Equations.
- Able to demonstrate modeling of fractional order systems in physical world.
- Able to design fractional order controller.

Module	Detailed content	Hours
	Prerequisite: Basic linear control systems theory, elementary linear algebra, linear differential equations, complex analysis. Familiarization with computing tools.	
1	**Fractional Calculus:** Definitions of integer-order (IO) derivatives and integrals and their geometric and physical interpretations, Definition of Riemann-Liouville (RL) integration, fractional derivatives (FDs) of RL, Caputo and Grunwald-Letnikov (GL). Various geometrical and physical interpretations of these FDs, Computation of these FDs for some basic functions like constant, sine, cosine, ramp, exponential etc., Laplace and Fourier transforms of FDs.	05
2	**Fractional-order Differential Equations:** Study of Special Functions of the Fractional Calculus like Gamma function, Mittag-Leffler function, Dawson's function, Hypergeometric function, etc, Analysis of linear fractional-order differential equations (FDEs): formulation, Solution with different FDs, Initial conditions, Problem of initialization and the remedies.	07
3	**Fractional-order Modelling:** Concepts of 'memory' and 'non-locality' in real world and engineering systems, non-exponential relaxation, 'Mittag-Leffler' type decay and rise. Detailed analysis of fractional-order (FO) modeling of: electrical circuit elements like inductor, capacitor, dielectric relaxation and transmission lines, FO modeling of viscoelastic materials, concept of fractional damping, Models of basic circuits and mechanical systems using FO elements, Concept of anomalous diffusion, non-Gaussian probability density function and the development of corresponding FO model.	10
4	**Linear Fractional-order Systems:** Review of basic concepts of complex analysis, Concepts of multivalued functions, branch points, branch cuts, Riemann surface and sheets, Fractional-order transfer function (FOTF) representation, Concepts like commensurate and non-commensurate TFs,	08

	stability, impulse, step and ramp response, Frequency response, non-minimum phase systems, Root locus, FO pseudo state-space (PSS) representation and the associated concepts like solution of PSS model, controllability, observability, etc.	
5	**Fractional-order Control:** Detailed discussion and analysis of superiority of FO control over the conventional IO control in terms of closed-loop performance, robustness, stability, etc., FO lead-lag compensators, FO PID control, design of FO state-feedback, Realization and implementation issues for FO controllers, survey of various realization methods and the comparative study.	10
6	**Computational and Symbolic Algebra Software's for Fractional Calculus and FO Control:** Primer on MATLAB and Mathematica, Computation of FDs using MATLAB, Analytical expressions for FDs using Mathematica, Use of Mittag-Leffler functions and various special functions in MATLAB, Analysis of system of non-linear FDEs using these softwares, Use of simulink in analysis of FO systems and control.	08

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. K. B. Oldham and J. Spanier. "The Fractional Calculus". Dover Publications, USA, 2006.
2. A. A. Kilbas, H. M. Srivastava, and J. J. Trujillo, "Theory and Applications of Fractional Differential Equations".
   Elsevier, Netherlands, 2006.
3. I. Podlubny, "Fractional Differential Equations". Academic Press, USA, 1999.
4. C. A. Monje, Y. Q. Chen, B. M. Vinagre, D. Xue, and V. Feliu, "Fractional-order Systems and Control:
   Fundamentals and Applications" Springer-Verlag London Limited, UK, 2010.
5. R. Caponetto, G. Dongola, L. Fortuna, and I. Petras, "Fractional Order Systems: Modeling and Control
   Applications", World Scientific, Singapore, 2010.
6. K. S. Miller and B. Ross, "An Introduction to the Fractional Calculus and Fractional Differential Equations", John Wiley & Sons, USA, 1993.
7. S. Das "Functional Fractional Calculus for System Identification and Controls", Springer, Germany, 2011.
8. M. D. Ortigueira, "Fractional Calculus for Scientists and Engineers", Springer, Germany, 2011.

9. Petras, “Fractional-Order Nonlinear Systems: Modelling, Analysis and Simulation”, Springer, USA, 2011.
10. W. R. LePage, “Complex Variables and the Laplace Transform for Engineers”, Dover Publications, USA, 2010.
11. H. Ruskeepaa, “ Mathematica Navigator: Mathematics, Statistics and Graphics”, Academic Press, USA, 2009.

Subject Code	Subject Name	Credits
ISDLO2022	ADVANCED NUCLEAR INSTRUMENTATION	04

Course Objectives:

- To explain fundamentals of nuclear reactions and their principles.
- To create awareness of nuclear reactors for operation and safety.
- To familiarize the concepts of various radiation detectors and its classification.
- To train them with nuclear study in research and medical field.

Course Outcomes:

- Demonstrate importance of nuclear energy, different instrumentation techniques for reactor control.
- Ability to get well versed with construction and working of various radiation detectors.
- Develop knowledge of electronics and counting systems used in advanced nuclear instrumentation.
- To advance with information about applications of nuclear instrumentation in various fields such as medicine, industry and research.

Module	Detailed content	Hours
	Prerequisite: Basics of nuclear energy, radioactivity, properties of alpha, beta and gamma rays, radioactivity laws, Isotopes and isobars, various effects of radioactivity, safety standards, nuclear waste disposal system.	
1	**Radiation Detectors:** Properties of Radiation Detectors, Modes of Detector operation, Pulse height spectra, Counting curves & plateaus, Energy resolution, Detection efficiency, Scintillation detectors, Solid state detectors Ge(Li), Si(Li) detectors	06
2	**Instrumentation for Reactor:** Log and linear amplifiers, Neutron detector, Boron trifluoride detector (BF3), Fission Counters, Basic control concepts of PWR, Reactor power control for a PWR, Turbine control, Steam generators, Volume and boron concentration control systems, Reactor pressure control,Basic control concept of BWR, Reactivity parameters in a BWR core, BWR control concepts, BWR control systems, Pressure and turbine speed control, Control of the vessel's water level, Core power control, Control rod control, other control systems, Self-power detectors.	10
3	**Neutron Detection and Spectroscopy:** Fast neutron detection methods- Counters based on neutron moderation, Detectors based on fast neutron induced reactions, Detectors that utilize fast neutron scattering, Slow neutron detection methods- Nuclear reactions of interest in neutron detection, Detectors based on boron reaction, Detectors based on other conversion reactions, Reactor instrumentation, Liquid Scintillation Counting systems, Noise reduction by coincidence detection technique.	08

4	**Nuclear Instrumentation for Research:** Radiation detectors for high resolution nuclear pulse spectroscopy, HPGE, high resolution Multi Channel Analyzers, Nuclear ADCs, Wilkinson, Gatti's sliding scale technique, various modes of Multi-Channel Analyser, portable spectroscopy systems and their design. Timing spectroscopy, TDCs, TACs, spectrum stabilization. Instrumentation for accelerators, Detection of cosmic events, detector arrays.	10
5	**Nuclear Medical Instrumentation:** Functional imaging, Design and Construction of Imaging Systems, Scintillation Camera, PET, SPECT systems, SPECT/PET Hybrid Systems, Calibrations and testing of various nuclear instruments and systems.	06
6	**Reactor Safety Systems:** Emergency coolant injection, Containment, Dousing system, Containment isolation control, Heavy-water leak detection, failed fuel detection system, Design requirements- Redundancy, physical separation, diversity and failure to safety, Environmental influences, safety instrumented systems.	08

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. G.F.Knoll, "Radiation detection and measurement", John Wiely and Sons, 4th edition, 2010.
2. P.W. Nicolson, "Nuclear electronics", John Wiely,1998.
3. Gerald. J.Hine, James A Sorenson, "Instrumentation in nuclear Medicine", Vol II, Academic Press, 1974
4. Ramesh Chandra, "Nuclear Medicine Physics", Williams and Wilkins, 1998.
5. Irving Kaplan, "Nuclear Physics", Narosa Publishing House.1992.
6. Technical Reports Series No.239, "A Guidebook Nuclear Power Plant Instrumentation And Control" International Atomic Energy Agency, Vienna, 1984.
7. B.R.Bairi, Balvinder Singh, N.C. Rathod, P.V. Narurkar, "Hand Book of Nuclear Medical Instruments", TMH Publishing, New Delhi, 1974.
8. Hidekazu Yoshikawa, Zhijian Zhang, "Progress of Nuclear Safety for Symbiosis and Sustainability", Springer Japan, 2014.
9. Yoshiaki Oka, "Nuclear Reactor Design", volume 2, Springer Japan, 2014.
10. Yoshiaki Oka, Seiichi Koshizuka, Yuki Ishiwatari, AkifumiYamaji, "Super Light Water Reactors and Super-Fast Reactors", Springer US, 2010.

Subject Code	Subject Name	Credits
ISDLO2023	WAVELETS AND APPLICATIONS	04

Course Objectives:

- To impart the importance of wavelets
- To explain the fundamentals of wavelet theory
- To familiarize with the most commonly used wavelets
- To create awareness of selection procedure of wavelets
- To familiarize with the construction of different types of wavelets

Course Outcomes:

- Able to develop concepts of using wavelets for various signal processing applications.
- Inculcate concepts, theory and algorithms behind wavelets from an interdisciplinary perspective and able to make use of wavelets for various applications.
- Ability to apply wavelets for digital signal processing and other multimedia signal processing subjects.

Module	Detailed content	Hours
	Prerequisite: Review of Fourier Transform, Parseval Theorem and need for joint time-frequency Analysis. Concepts of non-stationary signals, Short time Fourier transform (STFT), Uncertainty Principle, Localization / Isolation in time and frequency, Hilbert Spaces, Banach Spaces and Fundamentals of Hilbert Transform.	
1	**Introduction:** Daubechies Wavelet Bases, Daubechies compactly supported family of wavelets,Daubechies filter coefficient calculations, Case study of Daub-4 filter design, Connection between Haar and Daub-4, Concept of Regularity, Vanishing moments. Other classes of wavelets like Shannon, Meyer, Battle-Lamarie.	06
2	**Continuous Wavelet Transform:** Continuous time frequency representation of signals, The Windowed Fourier Transform, Uncertainty Principle and time frequency tiling, Wavelets, specifications, admissibility conditions, Continuous wavelet transform, CWT as a correlation, CWT as an operator, Inverse CWT.	10
3	**Discrete wavelet Transform:** Approximations of vectors in nested linear vector spaces, Example of an MRA, Formal definition of MRA, Construction of genera orthonormal MRA, a Wavelet basis for MRA, Digital filtering interpretations Decomposition and Reconstruction filters, examples of orthogonal basis generating wavelets, Interpreting orthonormal MRA for Discrete time signals, Mallat algorithm Filter bank implementation of DWT	10
4	**Orthogonal Wavelets:** Orthogonality in vector space, Orthogonal wavelet bases, Signal representation using Orthogonal wavelet system, advantages of orthogonal wavelets, orthogonal analysis and synthesis, Filter bank	06

	implementation, Constructing Orthonormal Wavelet Bases, Lapped Orthogonal Transforms.	
5	**Alternative wavelet representations Biorthogonal Wavelets:** Biorthogonality in vector space, biorthogonal wavelet bases, signal representation using biorthogonal wavelet system, advantages of biorthogonal wavelets, biorthogonal analysis and synthesis, Filter bank implementation, Two dimensional Wavelets, filter bank implementation of two dimensional wavelet transform. Lifting scheme: Wavelet Transform using polyphase matrix factorization, Geometrical foundations of the lifting scheme, lifting scheme in the z-domain, mathematical preliminaries for polyphase factorization, Dealing with Signal Boundary.	10
6	**Applications:** Image Compression: EZW Coding, SPIHT, Wavelet Difference Reduction Compression Algorithm, Denoising, speckle removal, edge detection and object isolation, audio compression, communication applications – scaling functions as signaling pulses, Discrete Wavelet Multi-tone Modulation.	06

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Stephen G. Mallat, "A wavelet tour of signal processing", 2nd Edition Academic Press, 2000.
2. M. Vetterli, J. Kovacevic, "Wavelets and subband coding", Prentice Hall Inc, 1995
3. Gilbert Strang and Truong Q. Nguyen, "Wavelets and filter banks", 2nd Edition Wellesley-Cambridge Press,1998.
4. Gerald Kaiser, "A friendly guide to wavelets", Birkhauser/Springer International Edition, 1994, Indian reprint 2005.
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6. J. C. Goswami and A. K. Chan, "Fundamentals of wavelets: Theory, Algorithms and Applications", Wiley-Interscience Publication, John Wiley & Sons Inc., 1999.
7. Mark A. Pinsky, "Introduction to Fourier Analysis and Wavelets", Brooks/Cole Series in Advanced Mathematics, 2002.
8. Raghuveer Rao and Ajit Bopardikar, "Wavelet Transforms: Introduction to Theory and Applications", Pearson Education, 1998.
9. K P Soman, K I Ramchandran, "Insight Into Wavelets - From Theory to Practice", PHI publication (2nd edition), Prentice Hall of India, 2010.

10. R. Gonzalez, R. Woods , “Digital Image Processing”, 3rd Edition**,** Pearson Education, 2008.
11. P. P. Vaidyanathan , “Multirate Systems and Filter Banks”, Pearson Education, 1993.
12. Jayaraman, “Digital Image Processing”, Tata McGraw-Hill Education, 2011.
13. Rafael C. Gonzalez , Richard E. Woods, Steven L. Eddins, “Digital Image Processing Using MATLAB” , 2nd edition, Gatesmark Publishing, 2009.

Subject Code	Subject Name	Credits
ISDLO2024	SOFT COMPUTING TECHNIQUES	04

Course Objectives:

- To familiarize with soft computing concepts.
- To teach about the concept of fuzziness involved in various systems.
- To expose the ideas about genetic algorithm.
- To provide adequate knowledge about of FLC and NN toolbox.
- To innovate many real world control problems.

Course Outcomes:

- Ability to apply the knowledge of basic neural networks paradigms.
- Demonstrate the basic concepts of training in neural networks.
- Able to apply the techniques for identification and control of the nonlinear processes.
- Able to inculcate adequate knowledge about Genetic algorithm.
- Able to implement Hybrid Control system.

Module	Detailed content	Hours
	Prerequisite: Introduction of soft computing - soft computing vs. hard computing, various types of soft computing techniques, and applications of soft computing. Biological Neural Networks, Neuron Physiology, Fuzzy sets and Basic notions.	
1	**Neural System:** Artificial Neuron Model, Operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architectures, Classification Taxonomy of ANN - Connectivity, Neural Dynamics (Activation and Synaptic), Learning Strategy (Supervised, Unsupervised, and Reinforcement), Learning Rules, and Multilayer feed forward Neural Networks.	08
2	**Artificial Neural Networks:** Counter propagation network- architecture- functioning & characteristics of counter Propagation network-Hopfield/ Recurrent network- configuration- stability constraints associative memory- and characteristics- limitations and applications- Hopfield v/s Boltzman machine- Adaptive Resonance Theory- Architecture- classifications Implementation and training-Associative Memory.	08
3	**Fuzzy logic systems:** Introduction to crisp sets and fuzzy sets- basic fuzzy set operation and approximate reasoning. crisp relations, fuzzy relations. Introduction to fuzzy logic modeling and control- Fuzzification, inferencing and defuzzification-Fuzzy knowledge and rule bases-Fuzzy modeling and control schemes for nonlinear systems. Self-organizing fuzzy logic control- Fuzzy logic control for nonlinear time delay system.	10
4	**Genetic Algorithm:** 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	08

	techniques like tabu search and ant colony search techniques for solving optimization problems.	
5	**Hybrid Control:** Genetic Algorithm, Neuro-Fuzzy, Fuzzy-GA and Neuro-Fuzzy-GA based hybrid system design.	06
6	**Applications:** Case Studies of Neural network : Pattern recognition, control and Process Monitoring, fault diagnosis and load forecasting. Case studies of Fuzzy logic : Greg viot's fuzzy cruise controller, Air conditioner controller. System identification, design and implementation of linear and nonlinear control systems using computing tools such as NN, GA and Fuzzy logic.	08

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Devendra K. Chaturvedi, "Soft Computing Techniques and its Applications in Electrical Engineering," Vol. 103, Studies in Computational Intelligence, Springer, 2008.
2. Hagan, Demuth, Beale- Thomas Learning , "Neural Network Design," Vikas Publishing House.
3. Jacek M. Zuarda, " Introduction to Artificial Neural Systems," Jaico Publishing House, 1997.
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5. S.N. Sivanandan and S.N. Deepa, "Principles of Soft Computing," Wiley India, 2007.
6. N. Yadaiah and S. BapiRaju, "Neural and Fuzzy Systems: Foundation, Architectures and Applications," Pearson Education.
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8. J.S.R.Jang, C.T.Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing," Pearson Education, PHI, 2004.
9. S. Rajasekaran and G.A.V.Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms," PHI, 2003.

Subject Code	Subject Name	Credits
ISDLO2025	INSTRUMENTATION FOR ENVIRONMENTAL ANALYSIS	04

Course Objectives:

- To teach the origin and evolution of environmental science.
- To familiarize with the environmental problems and their solutions.
- To train students with the concepts of environmental monitoring and its significance.

Course Outcome:

- Able to apply concepts of environmental balance management.
- Demonstrate different types of pollution and their causes.
- Ability to create awareness of different instrumentation techniques for solutions of natural life cycle problems.
- Able to implement various strategies for pollution control and environmental balance.

Module	Detailed Content	Hours
	Pre-requisite: Bio-diversity, Earth's Natural Cycles (Rock, Carbon, Water, Nitrogen), importance of air, water, sound, soil in nature balance, cycle of seasons and their balance.	
1	**Environmental management:** Definition of Environment, Earth, Man and Environment, Evolution of environment, Necessity of instrumentation & control for environment, sensor requirement for Environment. Scope for instrumentation in environmental management, basic concepts of sustainable development, industrial ecology and recycling industry.	08
2	**Air Pollution:** Natural and anthropogenic sources of pollution, importance of air pollution control, Air monitoring: measurement of ambient air quality.air pollution from thermal power plant, their characteristics & control, Instrumentation for air pollution control and HVAC systems	08
3	**Water Pollution:** Types of sources and consequences of water pollution, Analysis of water quality, standards, Instrumentation for sewage and waste water treatment (UV, H_2O_2, Ozonization) and recycling, Measurement techniques for water quality and standards.	08
4	**Thermal pollution:** Definition and sources, Chemical and biological effects of thermal pollution, Effect on marine life, bacteria and water quality and other aquatic biota; Thermal pollution from power plants and their control.	08
5	**Oil Pollution and Electronic waste (E-waste):** Oil pollution and marine ecology, sources of oil pollution, factors effecting fate of oil after spillage movement, spreading, evaporation, emulsification, dispersion, remote sensing in water quality monitoring. Sources and types and constituents of E-wastes and its environmental consequences.	08

6	**Noise Pollution:** Measurement of sound, effects of noise pollution on health, noise level standard in industrial, commercial, residential and silence zones and respective control strategies. **Soil Pollution:** Sources, nature, classification and environmental effects. Types, effects, sources and measurement of soil pollution, control techniques, standards for soil quality.	08

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Randy D. Down, "Environmental Instrumentation & Analysis Handbook", Wiley 2005.
2. S.P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill, 1985.
3. K.V.S.G. Murlikrishan, "Air pollution and control", Laxmi Publication 2015.
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   Prentice Hall, 2008.
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Subject Code	Subject Name	Credits
ISDLO2026	ROBOTICS AND AUTOMATION	04

Course Objectives:

- To motivate students with the various parts of robots and fields of robotics.
- To explain kinematics and inverse kinematics of robots.
- To expand concepts of Euler, Lagrangian formulation of Robot dynamics.
- To design and formulate the trajectory planning for robot.
- To facilitate students with the control of robots for some specific applications.

Course Outcomes:

- Ability to demonstrate the concept of Robots and Robot Kinematics.
- Able to apply the Dynamics of Robots.
- Ability to develop the Robot Vision applications.
- Ability to expand the control of robots for some specific applications.

Module	Detailed content	Hours
	Prerequisite: Components and mechanisms of Robotic system- Robotic classifications- Introduction to Robot's kinematics- dynamics and control.	
1	**Introduction and Robot Kinematics:** Basic concepts of Robots and automation- Classification-Specifications- Application Notation- Direct Kinematics-Co-ordinate frames-rotations- Homogeneous Coordinates- The Arm equation- Kinematic analysis of a typical Robot-Inverse Kinematics- Tool configuration- Inverse kinematics of a typical Robot-Workspace analysis and trajectory planning- Work envelope of different robots- The pick and place operation.	10
2	**Dynamic of Robots:** Continuous path motion-interpolated motion-Straight line motion- Tool configuration Jacobian matrix and manipulator Jacobian-Manipulator Dynamics- Kinetic of potential energy-Energized forces- Lagrange's Equation- Euler Dynamic model.	08
3	**Robot Control:** The control problem- State equation-Single axis PID control-PD gravity control- Computed torque control- Variable Structure control- Impedance control.	06
4	**Robot Vision:** Fundamentals of Robot applications-Robot vision-Image representation- Template matching-polyhedral objects-Shape analysis- Segmentation- Iterative processing -Robot cell design- Types of applications-material handling applications- Machine loading and unloading- Spot welding-arc welding- Spray painting.	10
5	**Micro Robotics:** Micro Robotics and MEMS-Fabrication technology for micro robotics- Stability issues in legged robots- Under actuated manipulators.	06
6	**Mobile Robots and Control Issues:** Industrial automation- General layout-general configuration of an automated flow line conveyor	08

	systems- Major feature - Types- Roller- State wheel- Belt- Chain and Overhead Trolley-Inspection station with feedback loops to up steam workstations- Shop floor control- 3 phases- Order scheduling.	

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

References:

1. Klafter R.D., Chimielewski T.A., Negin M., "Robotic Engineering – An integrated approach", Prentice Hall of India, New Delhi, 3rd June 2016.
2. SaeedB.Niku, "Introduction to robotics- Analysis, Control, Applications", 2nd Edition August, 2010.
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4. K.S. Fu, R. C. Gonzally, C.S. G. Lee, "Robotics Control, sensing, Vision and Intelligence", McGraw Hill Book Company, 2008.
5. Thomas R. Kurfess, "Robotics and Automation Handbook", October 15, CRC Press, 2004.
6. Robert Joseph Schilling, "Fundamentals of Robotics: Analysis and Control", Prentice Hall of India Pvt. Ltd.,2002.
7. Mikell P. Groover, Mitchell Weiss, Roger. N. Nagel, Nicholas G. Odrey, "Industrial Robotics Technology Programming and Application" - McGraw Hill Book Company, 1987.

Subject Code	Subject Name	Credits
ILO2021	PROJECT MANAGEMENT	03

Objectives:

- To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques.
- To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.

Outcomes: Learner will be able to…

- Apply selection criteria and select an appropriate project from different options.
- Write work break down structure for a project and develop a schedule based on it.
- Identify opportunities and threats to the project and decide an approach to deal with them strategically.
- Use Earned value technique and determine & predict status of the project.
- Capture lessons learned during project phases and document them for future reference

Module	Detailed Contents	Hrs
01	**Project Management Foundation:** Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager. Negotiations and resolving conflicts. Project management in various organization structures. PM knowledge areas as per Project Management Institute (PMI).	5
02	**Initiating Projects:** How to get a project started, Selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter; Project proposal. Effective project team, Stages of team development & growth (forming, storming, norming & performing), team dynamics.	6
03	**Project Planning and Scheduling:** Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart. Introduction to Project Management Information System (PMIS).	8
04	**Planning Projects:** Crashing project time, Resource loading and leveling, Goldratt's critical chain, Project Stakeholders and Communication plan. Risk Management in projects: Risk management planning, Risk identification and risk register. Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks	6
05	**Executing Projects:** Planning monitoring and controlling cycle. Information needs and reporting, engaging with all stakeholders of the projects. Team management, communication and project meetings. **Monitoring and Controlling Projects:** Earned Value Management techniques for measuring	8

	value of work completed; Using milestones for measurement; change requests and scope creep. Project audit. **Project Contracting:** Project procurement management, contracting and outsourcing,	
06	**Project Leadership and Ethics:** Introduction to project leadership, ethics in projects. Multicultural and virtual projects. C**losing the Project:** Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lessons learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study.	6

Assessment:

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End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. 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)
4. Only Four question need to be solved.

REFERENCES:

1. Jack Meredith & Samuel Mantel, Project Management: A managerial approach, Wiley India, 7th Ed.
2. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 5th Ed, Project Management Institute PA, USA
3. Gido Clements, Project Management, Cengage Learning.
4. Gopalan, Project Management, , Wiley India
5. Dennis Lock, Project Management, Gower Publishing England, 9 th Ed.

Subject Code	Subject Name	Credits
ILO2022	FINANCE MANAGEMENT	03

Objectives:

1. Overview of Indian financial system, instruments and market
2. Basic concepts of value of money, returns and risks, corporate finance, working capital and its management
3. Knowledge about sources of finance, capital structure, dividend policy

Outcomes: Learner will be able to…

1. Understand Indian finance system and corporate finance
2. Take investment, finance as well as dividend decisions

Module	Detailed Contents	Hrs
01	**Overview of Indian Financial System:** Characteristics, Components and Functions of Financial System. **Financial Instruments:** Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills. **Financial Markets:** Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market. **Financial Institutions:** Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges	06
02	**Concepts of Returns and Risks:** Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio. **Time Value of Money:** Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting.	06
03	**Overview of Corporate Finance:** Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision. **Financial Ratio Analysis:** Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.	09
04	**Capital Budgeting:** Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR) **Working Capital Management:** Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity's Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of	10

	Cash and Marketable Securities.	
05	**Sources of Finance:** Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance. **Capital Structure:** Factors Affecting an Entity's Capital Structure; Overview of Capital Structure Theories and Approaches— Net Income Approach, Net Operating Income Approach; Traditional Approach, and Modigliani-Miller Approach. Relation between Capital Structure and Corporate Value; Concept of Optimal Capital Structure	05
06	**Dividend Policy:** Meaning and Importance of Dividend Policy; Factors Affecting an Entity's Dividend Decision; Overview of Dividend Policy Theories and Approaches—Gordon's Approach, Walter's Approach, and Modigliani-Miller Approach	03

Assessment:

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4. Only Four question need to be solved.

REFERENCES:

1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.
4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

Subject Code	Subject Name	Credits
ILO2023	ENTERPRENEURSHIP DEVELOPMENT AND MANAGEMENT	03

Objectives:

- To acquaint with entrepreneurship and management of business
- Understand Indian environment for entrepreneurship
- Idea of EDP, MSME

Outcomes: Learner will be able to…

- Understand the concept of business plan and ownerships
- Interpret key regulations and legal aspects of entrepreneurship in India
- Understand government policies for entrepreneurs

Module	Detailed Contents	Hrs
01	**Overview Of Entrepreneurship:** Definitions, Roles and Functions/Values of Entrepreneurship, History of Entrepreneurship Development, Role of Entrepreneurship in the National Economy, Functions of an Entrepreneur, Entrepreneurship and Forms of Business Ownership Role of Money and Capital Markets in Entrepreneurial Development: Contribution of Government Agencies in Sourcing information for Entrepreneurship	04
02	**Business Plans And Importance Of Capital To Entrepreneurship:** Preliminary and Marketing Plans, Management and Personnel, Start-up Costs and Financing as well as Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks, Assumptions and Conclusion, Capital and its Importance to the Entrepreneur **Entrepreneurship And Business Development:** Starting a New Business, Buying an Existing Business, New Product Development, Business Growth and the Entrepreneur Law and its Relevance to Business Operations	09
03	Women's Entrepreneurship Development, Social entrepreneurship-role and need, EDP cell, role of sustainability and sustainable development for SMEs, case studies, exercises	05
04	**Indian Environment for Entrepreneurship:** key regulations and legal aspects , MSMED Act 2006 and its implications, schemes and policies of the Ministry of MSME, role and responsibilities of various government organisations, departments, banks etc., Role of State governments in terms of infrastructure developments and support etc., Public private partnerships, National Skill development Mission, Credit Guarantee Fund, PMEGP, discussions, group exercises etc	08
05	**Effective Management of Business:** Issues and problems faced by micro and small enterprises and effective management of M and S enterprises (risk management, credit availability, technology innovation, supply chain management, linkage with large industries), exercises, e-Marketing	08
06	**Achieving Success In The Small Business:** Stages of the small business life	05

	cycle, four types of firm-level growth strategies, Options – harvesting or closing small business Critical Success factors of small business	

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4. Only Four question need to be solved.

REFERENCES:

1. Poornima Charantimath, Entrepreneurship development- Small Business Enterprise, Pearson
2. Education Robert D Hisrich, Michael P Peters, Dean A Shapherd, Entrepreneurship, latest edition, The McGrawHill Company
3. Dr TN Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi
4. Dr CN Prasad, Small and Medium Enterprises in Global Perspective, New century Publications, New Delhi
5. Vasant Desai, Entrepreneurial development and management, Himalaya Publishing House
6. Maddhurima Lall, Shikah Sahai, Entrepreneurship, Excel Books
7. Rashmi Bansal, STAY hungry STAY foolish, CIIE, IIM Ahmedabad
8. Law and Practice relating to Micro, Small and Medium enterprises, Taxmann Publication Ltd.
9. Kurakto, Entrepreneurship- Principles and Practices, Thomson Publication
10. Laghu Udyog Samachar
11. www.msme.gov.in
12. www.dcmesme.gov.in
13. www.msmetraining.gov.in

Subject Code	Subject Name	Credits
ILO2024	HUMAN RESOURCE MANAGEMENT	03

Objectives:

- To introduce the students with basic concepts, techniques and practices of the human resource management.
- To provide opportunity of learning Human resource Management (HRM) processes, related with the functions, and challenges in the emerging perspective.
- To familiarize the students about the latest developments, trends & different aspects of HRM.
- To acquaint the student with the importance of behavioral skills, Inter- personal, inter- group in an organizational setting.
- To prepare the students as future organizational change facilitators, stable leaders and managers, using the knowledge and techniques of human resource management.

Outcomes: Learner will be able to…

- Gain knowledge and understand the concepts about the different aspects of the human resource management.
- Understand and tackle the changes and challenges in today's diverse, dynamic organizational setting and culture.
- Utilize the behavioral skill sets learnt, in working with different people, teams & groups within the national and global environment.
- Apply the acquired techniques, knowledge and integrate it within the engineering/ non engineering working environment emerging as future engineers and managers.

Module	Detailed Contents	Hrs
01	**Introduction to HR:** Human Resource Management- Concept, Scope and Importance, Interdisciplinary Approach Relationship with other Sciences, Competencies of HR Manager, HRM functions. Human resource development (HRD): changing role of HRM – Human resource Planning, Technological change, Restructuring and rightsizing, Empowerment, TQM, Managing ethical issues.	5
02	**Organizational Behavior (OB) :** Introduction to OB Origin, Nature and Scope of Organizational Behavior, Relevance to Organizational Effectiveness and Contemporary issues, Personality: Meaning and Determinants of Personality, Personality development, Personality Types, Assessment of Personality Traits for Increasing Self Awareness, Perception: Attitude and Value, Effect of perception on Individual Decision-making, Attitude and Behavior. Motivation: Theories of Motivation and their Applications for Behavioral Change (Maslow, Herzberg, McGregor); Group Behavior and Group Dynamics: Work groups formal and informal groups and stages of group development. Team Effectiveness: High performing teams, Team Roles, cross functional and self-directed team. Case study	7
03	**Organizational Structure & Design :** Structure, size, technology, Environment	6

	of organization; Organizational Roles & conflicts: Concept of roles; role dynamics; role conflicts and stress. Leadership: Concepts and skills of leadership, Leadership and managerial roles, Leadership styles and contemporary issues in leadership. Power and Politics: Sources and uses of power; Politics at workplace, Tactics and strategies.	
04	**Human resource Planning:** Recruitment and Selection process, Job-enrichment, Empowerment - Job-Satisfaction, employee morale. Performance Appraisal Systems: Traditional & modern methods, Performance Counseling, Career Planning. Training & Development: Identification of Training Needs, Training Methods	5
05	**Emerging Trends in HR :** Organizational development; Business Process Re-engineering (BPR), BPR as a tool for organizational development , managing processes & transformation in HR. Organizational Change, Culture, Environment, Cross Cultural Leadership and Decision Making**:** Cross Cultural Communication and diversity at work**,** Causes of diversity, managing diversity with special reference to handicapped, women and ageing people, intra company cultural difference in employee motivation.	6
06	**HR & MIS:** Need, purpose, objective and role of information system in HR, Applications in HRD in various industries (e.g. manufacturing R&D, Public Transport, Hospitals, Hotels and service industries **Strategic HRM** Role of Strategic HRM in the modern business world, Concept of Strategy, Strategic Management Process, Approaches to Strategic Decision Making; Strategic Intent – Corporate Mission, Vision, Objectives and Goals **Labor Laws & Industrial Relations** Evolution of IR, IR issues in organizations, Overview of Labor Laws in India; Industrial Disputes Act, Trade Unions Act, Shops and Establishments Act	10

Assessment:

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REFERENCES:

1. Stephen Robbins, Organizational Behavior, 16th Ed, 2013
2. V S P Rao, Human Resource Management, 3rd Ed, 2010, Excel publishing
3. Aswathapa, Human resource management: Text & cases, 6th edition, 2011
4. C. B. Mamoria and S V Gankar, Dynamics of Industrial Relations in India, 15th Ed, 2015, Himalaya Publishing, 15thedition, 2015
5. P. SubbaRao, Essentials of Human Resource management and Industrial relations, 5th Ed, 2013, Himalaya Publishing
6. Laurie Mullins, Management & Organizational Behavior, Latest Ed, 2016, Pearson Publications

Subject Code	Subject Name	Credits
ILO2025	PROFESSIONAL ETHICS AND CORPORAT SOCIAL RESONSIBILITY(CSR)	03

Objectives:

- To understand professional ethics in business
- To recognized corporate social responsibility

Outcomes: Learner will be able to…

- Understand rights and duties of business
- Distinguish different aspects of corporate social responsibility
- Demonstrate professional ethics
- Understand legal aspects of corporate social responsibility

Module	Detailed Contents	Hrs
01	**Professional Ethics and Business:** The Nature of Business Ethics; Ethical Issues in Business; Moral Responsibility and Blame; Utilitarianism: Weighing Social Costs and Benefits; Rights and Duties of Business	04
02	**Professional Ethics in the Marketplace:** Perfect Competition; Monopoly Competition; Oligopolistic Competition; Oligopolies and Public Policy **Professional Ethics and the Environment:** Dimensions of Pollution and Resource Depletion; Ethics of Pollution Control; Ethics of Conserving Depletable Resources	08
03	**Professional Ethics of Consumer Protection:** Markets and Consumer Protection; Contract View of Business Firm's Duties to Consumers; Due Care Theory; Advertising Ethics; Consumer Privacy **Professional Ethics of Job Discrimination:** Nature of Job Discrimination; Extent of Discrimination; Reservation of Jobs.	06
04	**Introduction to Corporate Social Responsibility:** Potential Business Benefits—Triple bottom line, Human resources, Risk management, Supplier relations; Criticisms and concerns—Nature of business; Motives; Misdirection. Trajectory of Corporate Social Responsibility in India	05
05	**rporate Social Responsibility:** Articulation of Gandhian Trusteeship rporate Social Responsibility and Small and Medium Enterprises (SMEs) in India, Corporate Social Responsibility and Public-Private Partnership (PPP) in India	08
06	**rporate Social Responsibility in Globalizing India:** Corporate Social Responsibility Voluntary Guidelines, 2009 issued by the Ministry of Corporate Affairs, Government of India, Legal Aspects of Corporate Social Responsibility—Companies Act, 2013.	08

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4. Only Four question need to be solved.

REFERENCES:

1. Business Ethics: Texts and Cases from the Indian Perspective (2013) by Ananda Das Gupta; Publisher: Springer.
2. Corporate Social Responsibility: Readings and Cases in a Global Context (2007) by Andrew Crane, Dirk Matten, Laura Spence; Publisher: Routledge.
3. Business Ethics: Concepts and Cases, 7th Edition (2011) by Manuel G. Velasquez; Publisher: Pearson, New Delhi.
4. Corporate Social Responsibility in India (2015) by Bidyut Chakrabarty, Routledge, New Delhi.

Subject Code	Subject Name	Credits
ILO2026	RESEARCH METHODOLOGY	03

Objectives:

- To understand Research and Research Process
- To acquaint students with identifying problems for research and develop research strategies
- To familiarize students with the techniques of data collection, analysis of data and interpretation

Outcomes: Learner will be able to…

- Prepare a preliminary research design for projects in their subject matter areas
- Accurately collect, analyze and report data
- Present complex data or situations clearly
- Review and analyze research findings

Module	Detailed Contents	Hrs
01	**Introduction and Basic Research Concepts**: Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Research methods vs Methodology, Need of Research in Business and Social Sciences , Objectives of Research, Issues and Problems in Research, Characteristics of Research: Systematic, Valid, Verifiable, Empirical and Critical	10
02	**Types of Research:** Basic Research, Applied Research, Descriptive Research, Analytical Research, Empirical Research, Qualitative and Quantitative Approaches	08
03	**Research Design and Sample Design** : Research Design – Meaning, Types and Significance, Sample Design – Meaning and Significance Essentials of a good sampling Stages in Sample Design Sampling methods/techniques Sampling Errors	08
04	**Research Methodology :** Meaning of Research Methodology, Stages in Scientific Research Process a. Identification and Selection of Research Problem b. Formulation of Research Problem c. Review of Literature d. Formulation of Hypothesis e. Formulation of research Design f. Sample Design g. Data Collection h. Data Analysis i. Hypothesis testing and Interpretation of Data j. Preparation of Research Report	08
05	**Formulating Research Problem:** Considerations: Relevance, Interest, Data Availability, Choice of data, Analysis of data, Generalization and Interpretation of analysis	04
06	**Outcome of Research:** Preparation of the report on conclusion reached, Validity Testing & Ethical Issues, Suggestions and Recommendation	04

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4. Only Four question need to be solved.

REFERENCES:

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers Distributors.
2. Kothari, C.R., 1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nded), Singapore, Pearson Education

Subject Code	Subject Name	Credits
ILO2027	IPR AND PATENTING	03

Objectives:

- To understand intellectual property rights protection system
- To promote the knowledge of Intellectual Property Laws of India as well as International treaty procedures
- To get acquaintance with Patent search and patent filing procedure and applications

Outcomes: Learner will be able to…

- understand Intellectual Property assets
- assist individuals and organizations in capacity building
- work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting

Module	Detailed Contents	Hr
01	**Introduction to Intellectual Property Rights (IPR)**: Meaning of IPR, Different category of IPR instruments - Patents, Trademarks, Copyrights, Industrial Designs, Plant variety protection, Geographical indications, Transfer of technology etc. **Importance of IPR in Modern Global Economic Environment:** Theories of IPR, Philosophical aspects of IPR laws, Need for IPR, IPR as an instrument of development	05
02	**Enforcement of Intellectual Property Rights:** Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, International agreements, International organizations (e.g. WIPO, WTO) activein IPR enforcement **Indian Scenario of IPR:** Introduction, History of IPR in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India, Procedure for submitting patent and Enforcement of IPR at national level etc.	07
03	**Emerging Issues in IPR:** Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc.	06
04	**Basics of Patents:** Definition of Patents, Conditions of patentability, Patentable and non-patentable inventions, Types of patent applications (e.g. Patent of addition etc), Process Patent and Product Patent, Precautions while patenting, Patent specification Patent claims, Disclosures and non-disclosures, Patent rights and infringement, Method of getting a patent	07
05	**Patent Rules:** Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treaties where India is a member (TRIPS agreement, Paris convention etc.)	08
06	**Procedure for Filing a Patent (National and International):** Legislation and Salient Features, Patent Search, Drafting and Filing Patent Applications, Processing of patent, Patent Litigation, Patent Publicationetc, Time frame and cost, Patent Licensing, Patent Infringement **Patent databases:** Important websites, Searching international databases	07

Assessment:

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4. Only Four question need to be solved.

REFERENCE BOOKS:

1. Rajkumar S. Adukia, 2007, A Handbook on Laws Relating to Intellectual Property Rights in India, The Institute of Chartered Accountants of India
2. Keayla B K, Patent system and related issues at a glance, Published by National Working Group on Patent Laws
3. T Sengupta, 2011, Intellectual Property Law in India, Kluwer Law International
4. Tzen Wong and Graham Dutfield,2010, Intellectual Property and Human Development: Current Trends and Future Scenario, Cambridge University Press
5. Cornish, William Rodolph&Llewelyn, David. 2010, Intellectual Property: Patents, Copyrights, Trade Marks and Allied Right, 7th Edition, Sweet & Maxwell
6. LousHarns, 2012, The enforcement of Intellactual Property Rights: A Case Book, 3rd Edition, WIPO
7. PrabhuddhaGanguli, 2012, Intellectual Property Rights, 1st Edition, TMH
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10. KompalBansal and PraishitBansal, 2012, Fundamentals of IPR for Engineers, 1st Edition, BS Publications

11. Entrepreneurship Development and IPR Unit, BITS Pilani, 2007, A Manual on Intellectual Property Rights,
12. Mathew Y Maa, 2009, Fundamentals of Patenting and Licensing for Scientists and Engineers, World Scientific Publishing Company
13. N S Rathore, S M Mathur, PritiMathur, AnshulRathi**,** IPR: Drafting,Interpretation of Patent Specifications and Claims**,** New India Publishing Agency
14. Vivien Irish, 2005,Intellectual Property Rights for Engineers,IET
15. Howard B Rockman, 2004, Intellectual Property Law for Engineers and scientists, Wiley-IEEE Press

Subject Code	Subject Name	Credits
ILO2028	PRODUCT LIFE CYCLE MANAGEMENT	03

Objectives:

- To familiarize with digital business concept
- To acquaint with E-commerce
- To give insights into E-business and its strategies

Outcomes: The learner will be able to …..

- Identify drivers of digital business
- Illustrate various approaches and techniques for E-business and management
- Prepare E-business plan

Module	Detailed content	Hours
1	**Introduction to Digital Business:** Introduction, Background and current status, E-market places, structures, mechanisms, economics and impacts Difference between physical economy and digital economy, **Drivers of digital business**- Big Data & Analytics, Mobile, Cloud Computing, Social media, BYOD, and Internet of Things(digitally intelligent machines/services) Opportunities and Challenges in Digital Business,	09
2	**Overview of E-Commerce: E-Commerce-** Meaning, Retailing in e-commerce-products and services, consumer behavior, market research and advertisement B2B-E-commerce-selling and buying in private e-markets, public B2B exchanges and support services, e-supply chains, Collaborative Commerce, Intra business EC and Corporate portals Other E-C models and applications, innovative EC System-From E-government and learning to C2C, mobile commerce and pervasive computing EC Strategy and Implementation-EC strategy and global EC, Economics and Justification of EC, Using Affiliate marketing to promote your e-commerce business, Launching a successful online business and EC project, Legal, Ethics and Societal impacts of EC	06
3	**Digital Business Support services**: ERP as e –business backbone, knowledge Tope Apps, Information and referral system, **Application Development:** Building Digital business Applications and Infrastructure	06
4	**Managing E-Business**-Managing Knowledge, Management skills for e-business, Managing Risks in e –business, Security Threats to e-business - Security Overview, Electronic Commerce Threats, Encryption, ryptography, Public Key and Private Key Cryptography, Digital Signatures, Digital Certificates, Security Protocols over Public Networks: HTTP, SSL, Firewall as Security Control, Public Key Infrastructure (PKI) for Security, Prominent Cryptographic Applications	06
5	**E-Business Strategy**-E-business Strategic formulation- Analysis of Company's Internal and external environment, Selection of strategy, E-business strategy into Action, challenges and E-Transition (Process of Digital Transformation)	04

6	**Materializing e-business: From Idea to Realization**-Business plan preparation **Case Studies and presentations**	08

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. 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)
4. Only Four question need to be solved.

REFERENCES:

1. A textbook on E-commerce**,** Er Arunrajan Mishra, Dr W K Sarwade,Neha Publishers & Distributors, 2011
2. E-commerce from vision to fulfilment, Elias M. Awad, PHI-Restricted, 2002
3. Digital Business and E-Commerce Management, 6th Ed, Dave Chaffey, Pearson, August 2014
4. Introduction to E-business-Management and Strategy, Colin Combe, ELSVIER, 2006
5. Digital Business Concepts and Strategy, Eloise Coupey, 2nd Edition, Pearson
6. Trend and Challenges in Digital Business Innovation, Vinocenzo Morabito, Springer
7. Digital Business Discourse Erika Darics, April 2015, Palgrave Macmillan
8. E-Governance-Challenges and Opportunities in : Proceedings in 2nd International Conference theory and practice of Electronic Governance
9. Perspectives the Digital Enterprise –A framework for Transformation, TCS consulting journal Vol.5
10. Measuring Digital Economy-A new perspective -DOI:10.1787/9789264221796-en OECD Publishing

Subject Code	Subject Name	Credits
ILO2029	ENVIRONMENTAL MANAGEMENT	03

Objectives:

1. Understand and identify environmental issues relevant to India and global concerns
2. Learn concepts of ecology
3. Familiarise environment related legislations

Outcomes: Learner will be able to…

1. Understand the concept of environmental management
2. Understand ecosystem and interdependence, food chain etc.
3. Understand and interpret environment related legislations

Module	Detailed Contents	Hrs
01	Introduction and Definition of Environment: Significance of Environment Management for contemporary managers, Career opportunities. Environmental issues relevant to India, Sustainable Development, The Energy scenario.	10
02	Global Environmental concerns : Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc.	06
03	Concepts of Ecology: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.	05
04	Scope of Environment Management, Role & functions of Government as a planning and regulating agency. Environment Quality Management and Corporate Environmental Responsibility	10
05	Total Quality Environmental Management, ISO-14000, EMS certification.	05
06	General overview of major legislations like Environment Protection Act, Air (P & CP) Act, Water (P & CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc.	03

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. 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)
4. Only Four question need to be solved.

REFERENCES:

1. Environmental Management: Principles and Practice, C J Barrow, Routledge Publishers London, 1999
2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing
3. Environmental Management, **T V Ramachandra and Vijay Kulkarni, TERI Press**
4. Indian Standard Environmental Management Systems — Requirements With Guidance For Use, Bureau Of Indian Standards, February 2005
5. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, Maclillan India, 2000
6. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC Press
7. Environment and Ecology, Majid Hussain, 3rd Ed. Access Publishing.2015

Subject Code	Subject Name	Credits
ISL201	LABORATORY-III	01

Course Objective:

- To develop the skills needed to represent the system in state space form.
- To impart knowledge required to design state feedback controller and state estimator.
- To impart knowledge and skills needed to classify singular points and construct phase trajectory using delta and isocline methods.
- To make the students understand the concepts of stability and introduce techniques to assess the stability of certain class of non-linear system.
- To make the students understand the various non-linear behaviors.

Course Outcome:

- Know the constructional details, principle of operation, and performance of different unit operations and their Instrumentation.
- Analyze dynamics of a linear system by solving system model/ equation or applying domain transformation.
- Realize the structure of a discrete time system and model its action mathematically.
- Examine a system for its stability, controllability and observability.
- Apply knowledge of control theory for practical implementations in engineering and network analysis.

Experiment No.	Title
1.	Computation of controllability and observability.
2.	Designing pole placement controller for solar tracking system.
3.	Design of full state observer for SISO/MIMO system.
4.	Determine the stability of the system and construct the Lyapunov function for wireless networks.
5.	Stability determination using Variable Gradient method.
6.	Extrimise andminimize for determining the Equilibrium points using EulersLagranges formula.
7.	Case study: Application of modern control theory in power electronics/ systems/ power converter.
8.	Construction of phase trajectory using delta and isocline methods.
9.	Estimate the response of SISO / MIMO system using MATLAB.

NOTE: Perform any six experiments from above list and two experiments from Department Elective Course.

Term work: Term work consists of performing 08 practical mentioned as above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners.

Subject Code	Subject Name	Credits
ISL202	LABORATORY-IV	01

Course Objective:

- To get the concept of industrial automation.
- To study different industrial applications using PLC and DCS.
- To get adequate knowledge about PLC, SCADA and DCS.
- Get knowledge of industrial communication.

Course Outcomes:

- Able to understand concept of Programmable logic controller (PLC) and develop programming knowledge of PLC.
- Able to acquire knowledge of Distributed Control System (DCS), detail Engineering, configuration and programming of DCS.
- Able to Interface PLC to Supervisory Control and Data Acquisition Systems (SCADA).
- Able to interface LabVIEW software with hardware for different applications.
- Acquainted with knowledge on basic industrial instrumentation.
- Able to carry out study of any Process Control plant.

Experiment No.	Title
1	Simulation of batch reactor control using PLC with GUI.
2	Simulation of paint manufacturing process using PLC with GUI.
3	Interfacing of PLC to any SCADA through Modbus protocol and/or OPC.
4	Simulation of Heat exchanger feedback control scheme using DCS.
5	Real time cascade control scheme using DCS.
6	Creating an analog –open loop and digital loop using DCS.
7	Configure and implement different alarms in DCS system.
8	Simulation of boilerdrum level control using DCS.
9	On-line monitoring and control using DCS.
10	Development of HMI using any SCADA package.
11	Case study on Industrial networking.
12	LabVIEW based remote triggered control of process loop.

NOTE: Perform any six experiments from above list and two experiments from Department Elective Course.

Term work: Term work consists of performing 08 practical mentioned as above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners.

Code	Subject Name	Credits
ISS301	SEMINAR	03

Guidelines for Seminar:

- Seminar should be based on thrust areas in Instrumentation Engineering.
- Students should undergo literature survey and identify the topic of seminar and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the topic and compile the report in standard format and present in front of Panel of Examiners appointed by the Head of the Department/Institute of respective Program.
- Seminar assessment should be based on following points:
  - Quality of Literature survey and Novelty in the topic.
  - Relevance to the specialization
  - Understanding of the topic
  - Quality of Written and Oral Presentation

IMPORTANT NOTE:

1. Assessment of Seminar will be carried out by a pair of Internal and External examiner. The external examiner should be selected from approved panel of examiners for Seminar by University of Mumbai, OR faculty from Premier Educational Institutions/Research Organizations such as IIT, NIT, BARC, TIFR, DRDO, etc. OR a person having minimum Post-Graduate qualification with at least five years' experience in Industries.

2. Literature survey in case of seminar is based on the broader area of interest in recent developments and for dissertation it should be focused mainly on identified problem.

3. At least 4-5 hours of course on Research Methodology should be conducted which includes Literature Survey, Problems Identification, Analysis and Interpretation of Results and Technical Paper Writing in the beginning of 3rd Semester.

Subject Code	Subject Name	Credits
ISD301/401	DISSERTATION (I AND II)	12 + 15

Guidelines for Dissertation:

- Students should do literature survey and identify the problem for Dissertation and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem. Students should attempt the solution to the problem by analytical/simulation / experimental methods. The solution to be validated with proper justification and compile the report in standard format.

Guidelines for Assessment of Dissertation-I:

- Dissertation-I should be assessed based on following points
  - Quality of Literature survey and Novelty in the problem
  - Clarity of Problem definition and Feasibility of problem solution
  - Relevance to the specialization
  - Clarity of objective and scope
- Dissertation-I should be assessed through a presentation by a panel of Internal examiners appointed by the Head of the Department/Institute of respective Program.

Guidelines for Assessment of Dissertation-II:

- Dissertation-II should be assessed based on following points
  - Quality of Literature survey and Novelty in the problem
  - Clarity of Problem definition and Feasibility of problem solution
  - Relevance to the specialization or current Research / Industrial trends
  - Clarity of objective and scope
  - Quality of work attempted
  - Validation of results
  - Quality of Written and Oral Presentation
- Dissertation-II should be assessed through a presentation jointly by Internal and External Examiners appointed by the University of Mumbai.

Students should publish at least one paper based on the work in reputed International/ National Conference / Refereed Journal.