OPEN ELECTIVE COURSE BASKETS
THE STUDENT CAN OPT ANY OPEN ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER, EXCEPT THE SUBJECT(S) WITH HIS/ HER OWN DEPARTMENT CODE.

Basket– 1 (4th Semester)

Basket– 2 (5th Semester)

Basket– 3 (7th Semester)

XEO741	Human Resource Management	85
XEO742	Medical Instrumentation and Assistive Technology	No Syllabus
HSO743	Shakespearean Tragedy	154

Basket– 4 (8th Semester)

Code	Subject Name	Page No.
MSO841	Marketing Research and Analytics	86
PHO841	Quantum Physics	87-88
BTO840	Industrial Biotechnology	88-89
CEO840	Finite Element Analysis and Applications	90-91
CEO841	Disaster Management and Mitigation	91-92
CEO842	Experimental Methods in Engineering	92-93
CHO841	Bioengineering & Industrial applications	93-94
CHO842	Energy Integration and Economics in Process Industry	94-95
CSO841	CAD for VLSI	95-96
CSO842	Internet and Web Technologies	96-97
~~CSO843~~	~~Soft Computing Techniques~~	~~98-99~~
CSO844	Compiler Design	99-100
ECO840	Structronics	100-101
ECO841	Signal Processing	101-103
ECO842	Introduction to VLSI	103-104
ECO843	EMI / EMC	104-106
EEO840	Microgrid Systems	106-107
EEO841	Biomedical Instrumentation	107-108
EEO842	Renewable Energy	108-109
EEO843	Digital Image Processing	109-110
MEO841	Nonlinear Dynamical Systems	110-111
MMO841	Material Science	111-112
~~MMO842~~	~~Nanomaterials: Processing, Characterization and Properties~~	~~151-152~~
HSO840	Employability Skills and Workplace Communication	155

Basket– 5 (8th Semester)

Code	Subject Name	Page No.
HSO850	International Economics and Globalization	112
HSO851	Literature and Cinema	113
HSO852	Classics of Literature	114
HSO853	Public Speaking	115
MSO851	Investment Management and Stock Market	116
MSO852	Industrial Marketing	116-117
~~CYO851~~	~~Spectroscopic methods of chemical analysis~~	~~Removed~~
MAO851	Operations Research	118-119
MAO852	Advanced Numerical Analysis	119-120
MAO853	Optimization Techniques	120-121
PHO851	Fiber-Optics Communication	121-122

BASKET – 1

<table>
<tr><td colspan="7">Department of Humanities and Social Sciences</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>HSO440</td><td>Media, Culture and Technology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="4">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">None</td><td colspan="4">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="5">• CO1 Understanding key issues in Media Studies in international perspective
• CO2 Analyzing theoretical concepts in sociocultural contexts and exploring practical aspects</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="5">1. Introduction to Media Studies: Basic Theories and Concepts (4)
2. Use of Technology in Media Studies: Issues and Perspectives (4)
3. Approaches to Cultural Studies in Understanding Media and Society (4)
4. Visual Media: Images and Implications (4)
5. Popular Culture and Impact of Cinema (6)
6. Myths and Stereotypes in Media Representations (2)
7. Deconstructing Orientalism in Media (2)
8. Transnationalism and Cosmopolitanism in Media Studies (4)
9. Globalization and Gender Issues in Media (4)
10. Folk Media and its Impact (4)
11. Mass Media and Development Communication (2)
12. Emergence of New Media and Cyber Culture (2)</td></tr>
<tr><td colspan="2">Text Books, and/or reference material</td><td colspan="5">Recommended Readings:
1. Dasgupta, S., Sinha, D. Chakravarti, S. (2011). Media, gender and popular culture in India: Tracking change and continuity. Thousand Oaks, Calif. : Sage Publications
2. Durham, M. G., & Kellner, D. M. (Eds.). (2009). Media and cultural studies: KeyWorks. Massachusetts: Blackwell Publishers.
3. Graham, M. "Threshold of the Information Age: Radio, Television, and Motion Pictures Mobilize the Nation," in A. Chandler & J. Cortada eds. A Nation Transformed By Information. 2003.
4. Rai, M. & Cottle, S. "Global Mediations. On the Changing Ecology of Satellite Television News," Global Media and Communication. Vol. 3 (1), April 2007.
5. Gitlin, T. "Media Sociology: The Dominant Paradigm" Theory and Society, Vol. 6, No. 2 (Sep., 1978), pp. 205-253.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	2	-	-	3	2	-	3
CO2	-	-	-	-	-	2	-	-	3	2	-	3

<table>
<tr><td colspan="8">Department of Mathematics</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAO441</td><td>Discrete Mathematical Structures</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), Mid-term assessment (MA) and end assessment (EA))</td></tr>
<tr><td colspan="2">Set Theory</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To enable the students to apply the basic concept of Logic to solve engineering and Artificial Intelligence related problems.
• CO2: To enable the students to solve problems of combinatorics.
• CO3: Students will have knowledge of Graph Theory which arises in many engineering and physical problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to set theory; combination of sets; power sets; finite and infinite sets, Introduction to Combinatorics, Counting techniques, The inclusion-exclusion principle, The pigeon-hole principle and its applications, Recurrence relation, Generating function, Partial order relations; POSETS. [6]
Mathematical logic, Predicate logic, Basic logical operation, Truth tables, Logic proposition and proof, Notion of interpretation, Method of proofs, Validity, consistency and completeness. [6]
Propositional Calculus: Well-formed formulas, Tautologies, Equivalence, Normal forms, Truth of algebraic systems, Calculus of predicates, Different forms of the principle of mathematical induction. [5]
Relations, Equivalence relation and equivalence classes, Diagraphs, Computer representation of relations, Warshall's algorithm, Representations of relations by binary matrices and digraphs; operations on relations. Closure of a relations; reflexive, symmetric and transitive closures. [7]
Lattice Theory and Introduction to Boolean algebra and Boolean functions, Different representations of Boolean functions, Application of Boolean functions to synthesis of circuits, Composition of function, functions for computer Science, Permutation function and growth of functions. [5]
Introduction of discrete numeric functions, Asymptotic behavior, Generating functions, Linear recurrence relations with constant coefficients (homogeneous and non-homogeneous cases), Solution of linear recurrence relations using generating functions. [5]
Path, cycles, Handshaking theorem, Bipartite graphs, Sub-graphs, Graph isomorphism, Operations on graphs, Eulerian graphs and Hamiltonian graphs, Planar graphs, Euler formula, Traveling salesman problem, Shortest path algorithms, Minimum spanning tree algorithms, Maximum flow algorithms. [7]</td></tr>
</table>

Text Books, and/or reference material	**Text Books:** 1. Discrete Mathematics and its Applications - Kenneth H. Rosen 7th Edition -Tata McGraw Hill Publishers – 2007. 2. Elements of Discrete Mathematics, C. L Liu, McGraw-Hill Inc, 1985. Applied Combinatorics, Alan Tucker, 2007. **Reference Books:** 1. Concrete Mathematics, Ronald Graham, Donald Knuth, and Oren Patashnik, 2nd Edition - Pearson Education Publishers - 1996. 2. Combinatorics: Topics, Techniques, Algorithms by Peter J. Cameron, Cambridge University Press, 1994 (reprinted 1996). Topics in Algebra, I.N. Herstein, Wiley, 1975.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO 1	PO 2	PO 3	PO4	PO5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
MAO441	CO 1	3	3	3	2	3	2	1	-	-	-	1	2
	CO 2	3	2	3	3	2	1	1	-	1	-	1	1
	CO 3	3	3	2	3	2	2	2	1	-	1	3	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAO442	Probability and Stochastic Processes	PEL	3	0	0	3	3
Pre-requisites		Knowledge of differential and integral calculus, basics of probability at MAC02					
Course Outcomes	• CO1: To provide the basics of probability theory. • CO2: Introduce to students the probability models in physics, engineering, biology etc. • CO3: To highlight the roles of stochastic processes in physics, social science, finance etc.						
Topics Covered	**Introduction:** Axiomatic definition of Probability, Conditional Probability and Multiplication Rules, Stochastic independence, Baye's theorem and applications. (8) **Random Variables & Probability Distribution:** Random variables: Discrete and continuous, discrete and continuous probability distributions, Binomial and Poisson distribution, Normal distribution, Exponential distribution, Joint probability distributions, bivariate normal distribution. (6) **Mathematical Expectation:** Expectation of random variable, Properties of						

	Expectation, Variance and covariance of random variables, Means and variances of Linear Combinations of Random Variables, Conditional Expectations. Correlation coefficient. (6) **Functions of Random Variable**: Transformation of Variables, Moments and Moment Generating Functions, Characteristics functions, Normal Approximation to Binomial. (6) **Stochastic Processes:** Stochastic Process: definition and examples, Stationary Processes, Auto correlation, Auto Covariance, cross correlative coefficient, Martingales. (6) **Markov Chains**: Definitions and examples of Markov chains, Chapman-Kolmogorov Equations & classification of states, Ergodic Markov Chain, Applications of Markov chains, Time reversible Markov chains. (6) **Poisson Process**: Poisson Process, Inter-arrival & waiting time distributions, Non-homogeneous Poisson Process, Conditional Poisson process. (4)
Text Books, and/or reference material	**Text Books:** 1. T. Veerarajan: Probability, Statistics and Random Process, Tata McGraw-Hill Education, 2002. 2. Ronald E Walpole and Raymond H Myers: Probability and Statistics for Engineers and Scientists 3. J. Medhi, Stochastic Process, Wiley Eastern Limited, Second Edition, 1994. **Reference Book:** 1. C. Grinstead and J. Snell, Introduction to probability, American Mathematical Society, 1997. 2. Roy D Yates and David J. Goodman, Probability and stochastic processes, John Wiley and Sons, 1998.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAO442	CO1	3	3	3	3	2	1	-	1	1	1	1	1
	CO2	3	3	3	3	3	-	-	-	-	-	-	-
	CO3	3	3	3	3	3	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHO441	**Quantitative Biology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes		CO1: To see living systems from the perspective of engineering, physics, mathematics and computer science.					

	CO2: To understand systems based approaches in biological sciences. CO3: To use web-based resources that will help them in modeling complex biological processes. CO4: To choose an appropriate modeling technique for a complex biological system
Topics Covered	**Introduction to Nonlinear Phenomena** One-dimensional systems and elementary bifurcations, Two-dimensional systems; phase plane analysis, limit cycles, Nonlinear Oscillators, qualitative and approximate asymptotic techniques, Hopf bifurcations, chaos, strange attractors and fractals. [12] **Biological Networks and Motifs** Basic concepts in networks and chemical reactions. Input function of a gene, Michaelis-Menten kinetics, and cooperativity, Autoregulation, feedback and bistability, Introduction to synthetic biology and stability analysis in the toggle switch, Oscillatory genetic networks, Feed-forward loop network motif. [9] **Stochastic Modeling of Biological Systems** Concept of probability, Introduction to stochastic gene expression, Causes and consequences of stochastic gene expression, Markov processes and Markov Models, Stochastic modeling—The master equation, Fokker-Planck Equation, and the Gillespie algorithm, Survival in fluctuating environments, Robustness in development and pattern formation. [12] **Population Dynamics & evolutionary games** Interspecies interactions, the Lotka-Volterra model, and predator-prey oscillations, Ecosystem stability, critical transitions, and the maintenance of biodiversity, Infectious disease spread: SIR and other models, Introduction to microbial evolution experiments, and optimal gene circuit design, Fitness landscapes, Evolutionary games. [9]
Text Books, and/or reference material	**TEXT BOOKS:** **1.** Alon, Uri. *An Introduction to Systems Biology: Design Principles of Biological Circuits*. Chapman & Hall / CRC, 2006. ISBN: 9781584886426. **2.** Strogatz, Steven H. *Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering*. Westview Press, 2014. ISBN: 9780813349107. **3.** Network Science, A-L. Barabasi, Cambridge University Press **REFERENCE BOOKS:** **1.** Nowak, M. A. *Evolutionary Dynamics: Exploring the Equations of Life*. Belknap Press, 2006. ISBN: 9780674023383. **2.** Alberts, Bruce. *Essential Cell Biology*. Garland Science, 2009. ISBN: 9780815341291.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
PHO 441	CO1	3	2	2	1			2					1
	CO2	3	2	2	2			2					1
	CO3	3	2	2	3	3	2	1		1	1	1	1
	CO4	3	2	2	3	2	2	1	1	1			1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTO 441</td><td>FOOD BIOTECHNOLOGY</td><td>PER/OER</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">BTC01</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">CO1: To quantitate and identify the spoilage microorganisms present in food.
CO2: To learn the concepts of food fermentation and increase the shelf life of food.
CO3: To learn the concepts in genetically modified food and increase the agricultural yield by using genetic engineering approach.
CO4: To apply the concepts of antioxidant and nutraceutical for health and wellness.
CO5: To follow the regulations and ethical issues of food safety by using good manufacturing practices in industry and genetically modified food.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">Food Microbiology: [8]
Microorganism in food, Intrinsic and extrinsic parameters of food, rapid methods for identification of microorganism in food, Food borne illness, Biosensors –use and application
Food preservation [8]
Pasteurization, sterilization, Canning, thermal process of food with numericals, Irradiation, Dehydration, low temperature , use of preservatives
Food fermentation [10]
Role of lactic acid bacteria in fermentation and strain improvement, Fermentation of meat, fish, vegetables, beverages, dairy product, non-beverage product , use of genetic engineering techniques for improved quality product.
Genetically modified food [8]
Fruit ripening, amino acid, vitamin content, Golden rice. Safety aspects of genetically modified food, Ethical and regulatory issues
Biotechnology in relation to food product [4]
Antioxidant, nutraceutical,
Food safety [6]
Legal status of irradiated food and preservatives, Concept of HACCP, Hazop, codex alimentarius, ISO series, detection of toxin, heavy metal , pesticide and herbicides</td></tr>
</table>

Text Books, and/or reference material	Suggested Text Books: Food microbiology by James . M. Jay Food Microbiology by Frazier and Westhoff Plant Biotechnology by Slater Suggested Reference Books: Fundamentals of Food Biotechnology by Lee

Mapping of CO (Course Outcome) and PO (Programme Outcome)

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

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO440	**Introduction to Earthquake Engineering**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisites:	Course Assessment methods
No pre-requisites	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes	· CO1: Applying Engineering mathematics in solving vibration problem · CO2: Ability to design a building earthquake resistive · CO3: Learn basic of Earthquake engineering · CO4: Ability to manage disaster
Topics Covered	**Seismology:** Engineering geology of earthquakes, plate tectonics, Seismicity of the world, Seismic waves, faults, plate boundaries, Intensity, Strong ground motion, Measuring of Earthquake, Earthquake Magnitude-Local (Richter) magnitude, surface wave magnitude, Moment magnitude. Spectral Parameters: Peak Acceleration, Peak Velocity, Peak Displacement, Frequency Content and duration. **(12)** **Elementary Vibration:** Vibration of elementary system, Single degree and two-degree freedom systems, Earthquake analysis, Response spectrum concept **(10)** **Earthquake Resistant Design:** Philosophy, Code based methods for seismic design for RC buildings. Behaviour of masonry structure during earthquake, bands & reinforcement in masonry **(10)** **General Guidelines**: Efficient seismic resistant planning, selection of sites, importance of architectural features in earthquake resistant buildings,

	continuity of construction, projection special construction features like pounding, floating column, soft storey, stair case etc., role of engineers in the earth quake mitigations & disaster management **(10)**
Text Books, and/or reference material	***Text Books:*** 1. Earthquake resistant design of structures by Pankaj Agarwal and Manish Shrikhande 2. Basics of Structural dynamics and aseismic Design by S. R. Damodarasamy and S. Kavitha ***Reference Books:*** 3. Elements of Earthquake Engineering by Jai Krishna, A.R. Chandrasekharan, Brijesh Chandra

Mapping of Course Outcomes Cos→POs

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

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO441	**Elementary Civil Engineering**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods					
No pre-requisites		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes	· CO1: Gain knowledge about elementary level civil engineering · CO2: To learn the use of survey instruments · CO3: To learn about construction materials and technology						
Topics Covered	**Measurement:** Measurement of lengths, heights, and angles using surveying equipments, chain, tape, Dumpy level, staffs, Theodolites. **(10)** **Survey:** Different mapping methods, elements of chain surveying, compass surveying, plane table surveying, theodolite surveying, leveling and contouring. **(10)** **Building Materials:** Common building materials, stone, brick, timbers, cement, concrete, lime concrete, their strength, characteristics and different types of each material. **(10)** **Construction:** Elements of residential buildings, method of construction, miscellaneous temporary constructions, form work, timbering etc. **(12)**						

Text Books, and/or reference material	***Text Books:*** 1. Surveying and Levelling Part I by T. P. Kanetkar, and S. V. Kulkarni, Pune Vidyarthi Griha Prakashan Pune – 30, 1979 2. Engineering Materials by S. C. Rangwala, Charotar Pub. House, Anand 3. Building Construction by S. C. Rangwala, Charotar Pub. House, Anand ***Reference Books:*** 4. Building Construction by B. C. Punmia, A. K. Jain and A. K. Jain, Laxmi Publications (P) Ltd.

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO 5	PO6	PO7	PO 8	PO9	PO10	PO11	PO1 2
CO1	-	-	-	-	-	-	-	-	-	-	3	-
CO2	-	-	-	-	-	-	-	-	-	-	3	-
CO3	-	-	-	-	-	-	-	-	-	-	3	-

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO442	**Experimental methods and Analysis**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Basic Engineering, statistics & probability		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs):	· CO1: Development of skills for predicting engineering system behaviour · CO2: Knowledge of basics of data analysis for further applications. · CO3: Developing the requisite skill that helps in the advanced courses related to experimental study						
Topics Covered (Hrs)	**Types of measurements and errors**: Internal & external estimates of errors, Relative frequency distribution, Histogram, True value, Precision of measurement, Best estimate of true value & precision, Methods of calculating best estimate of true value & standard deviation **(7)** **Combination of measurements**: Accuracy of mean, Significant digits. Method of least squares & its application for calculation of best estimate of true value, curve fitting, **(8)** **General linear regression**: Comparison & combination of measurements. Extensions of least square method. Theory of errors, Binomial & Gaussian distribution, Confidence limits, Significance test, principle of maximum likelihood & goodness of fit, Chi-square test. **(9)** **Displacement measurement**: Dial Gauge, Microcator, Optical Method, Pneumatic Transducer, Strain Gauges, Variable Inductance & Capacitance Transducer, Piezo-Electric, Electro-Kinetic, Photo-Electric, Ionization, Vibrating Wire & Vacuum Tube Transducer. **Force & Torque:** Elastic Type, Fluid Load Cell, Dynamometers. **Temperature:** Bi-Materials, Pressure & Resistance Thermometers,						

	Thermocouples & Pyrometers. **Pressure:** McLeod Gauge, Pirani Gauge, Ionization Gauge, Manometers, Bourdon Tube, Resistance Gauges. **Fluid Velocity:** Pitot tube & Hot Wire Anemometer, LDA. Flow Measurement in Confined Passages & Open Channels. Miscellaneous measurements **(10)** **Dynamic Response** of a Measuring Instrument, Response to Transient & Periodic Signals, First & Second order systems as well as their Dynamic Response Characteristics. (**8)**
Text Books, and/or reference material (s)	***Text Books:*** 1. Instrumentation, Measurement and Analysis by B C Nakra and K K Chaudhary, Tata McGraw Hill, 1985. 2. Principles of Measurement, Precision, Error and Truth by N C Barford, Addison Wesley, 1967. ***Reference Books:*** 3. Physical Measurement and Analysis by N N Cook and E Rabinowicz, Addison Wesley, 1963 4. Experimental Methods for Engineers by J P Holman and W J Gajda, McGraw Hill Co., 1978

Mapping of Course Outcomes COsàPOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	2	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	-	-	1	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHO441	**PROCESS HEAT TRANSFER**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Nil		CT+MT+EA					
Course Outcomes	• CO1: Illustrate principles and laws of heat transfer of different heat exchanging phenomena • CO2**:** Solve heat transfer problems of different difficulty levels • CO3**:** Design and analyze heat transfer equipment						
Topics Covered	**Module I:** Mechanism of heat transmission: Conduction, Convection and Radiation. Conduction: Fourier's law; Steady-state heat transfer through composite slabs, cylinders and spheres; Optimum thickness of insulation; Unsteady-state heat transfer - use of Gurnie-Lurie chart, one and two-dimensional conduction in different geometry. [14 hrs.] **Module II:** Convection: Forced convection; Thermal boundary layer; Analogy between heat						

	and momentum transfer; Dimensional analysis of heat transfer; Heat transfer coefficients; Log-mean temperature difference; General equation for forced convection; Equivalent diameter; Natural convection; Condensation; Boiling of liquids. [10 hrs.] **Module III:** Radiation: Black body and Gray body; Laws of radiation; View factor; Radiant heat exchange between surfaces; Radiation from flame, gases and vapors. [7 hrs.] **Module IV:** Heat exchangers: Type of different heat exchangers and their design - Double pipe, Shell and tube, finned tube and Compact heat exchangers; Condensers and reboilers. **Evaporation:** Type of evaporators with accessories; Capacity and Steam economy; Boiling point rise/elevation; multiple effect evaporators; Design of single and multiple effect evaporators. [17 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Heat Transfer : Principles and Applications – Binay K. Dutta (Prentice-Hall India) 2. Process Heat Transfer – D. Q. Kern (McGraw-Hill) 3. A Text Book on Heat Transfer – S P Sukhatme (Universities Press) Suggested Reference Books: **1.** Heat Transmission – Mc Adams (McGraw-Hill)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	-	1	2	2	-	-	-	-	-	-	-	-
CO3	-	-	3	-	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 441	Data Structures and Algorithms	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
CSC-01 (Introduction to Computing)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Understanding the fundamental concepts of data, data types and abstract data types. • CO2: Implementation of different abstract data types using different data structures. • CO3: Design and development of algorithms for real-life applications. • CO4: Apply different types of data structures to implement different						

	algorithms.
Topics Covered	Introduction to problem solving through computer, Design of algorithm to solve a problem, Concept of static and dynamic memory allocation, Algorithms and data structures, Concept of Abstract Data Type (ADT) with examples. (4L) Efficiency of an algorithm, Time and space complexities, Impact of data structure on the performance of an algorithm. (3L) Array, Single and multi-dimensional array, Memory representation (row major and column major) of array, Insertion, and deletions in array, Advantages and disadvantages of array. (3L) Linked list as an ADT, Memory allocation and deallocation for a linked list, Linked list versus arrays, Types of linked lists: singly linked list, doubly linked list, circular linked list, Operations on linked list: creation, display, insertion and deletion (in different positions). (5L) Stack as an ADT, Main operations (push and pop), auxiliary operations and axioms, Array implementation of stack, Limitation of array implementation, Linked list implementation of stack, Applications of stack: Recursion, Function call, Evaluation of postfix expression using stack. Conversion from infix expression to its postfix version. (5L) Queue as an ADT, Main operations (enqueue and dequeue), Auxiliary operations and axioms, Array implementation of queue, Limitation of array implementation and Circular queue, Linked list implementation of queue, Priority queue and its applications. (4L) Trees, Definition and mathematical properties, Binary trees, Representation of binary trees in memory: linked representation, array representation, Binary tree traversal, Pre-order, Inorder, Post order, Expression trees, Heap and its applications, Search trees: Binary search trees, Balanced binary search trees. (8L) Searching and sorting: Linear search and binary search, Bubble, selection, insertion, Quick sort, Merge sort, Heap sort, Radix sort. (8L) Graphs: Mathematical Properties, Degree, Connectedness, Memory representation of graph: adjacency matrix, Adjacency list, Directed Graphs, Directed Acyclic Graph. (2L)
Text Books, and/or reference material	**Text Books:** 1. Lipschutz, "Data Structures (Schaum's Outline Series)", Tata Mcgraw Hill. 2. E. Horowitz, S. Sahni, S. Anderson-Freed, "Fundamentals of Data Structures in C", Universities Press; Second edition (2008). **Reference Books:** 1. Y. Langsam, M. J. Augenstein and A. N. Tanenbaum, "Data Structures using C and C++", Pearson, 2006. 2. Kleinberg and Eva Tardos. Algorithm Design. Addison-Wesley 2005 ISBN-13: 978-0321295354.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	1	2	1	1	1	1	2	2	1
CO2	3	2	3	1	2	1	1	1	1	2	2	1
CO3	2	3	3	1	2	1	1	1	3	2	3	1
CO4	2	3	3	1	2	1	1	1	3	2	3	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="8">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSO 442</td><td>Object Oriented Technology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3">CSO442 (Object Oriented Technology)</td><td colspan="5">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understanding of Object Oriented Design Approach and its real world applications
• CO2: Analyzing problems in terms of object oriented methodologies.
• CO3: Implement programs using concepts of classes and objects.
• CO4: Specify the forms of inheritance and use them in problem solving.
• CO5: Learn and implement different forms of polymorphism.
• CO6: Developing skills to write generic codes</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to problem solving through computer, Design of algorithm to solve a problem,
Concepts of functions, loops, strings, arrays, pointers, structures etc.
Procedure Oriented Programming, Object Oriented Programming, Objects and Classes, 3 basic features of OOP, Comparison of procedural programming and object oriented programming, C++ language, cout, cin operator, return type of main, structure of a C++ program, example with description, Tokens, keywords, identifiers, declaration of variables, dynamic initialization of variables, reference variables, scope resolution operator, difference between C and C++. Examples and Practice Sessions. (7L)
Declaration of classes and objects, member functions, accessing class members, inline function, Nesting of member function, Private member function, Static data members, static member function, Objects as function argument, Friend functions, structure and class, returning objects, Examples and Exercises. (5L)
Overview of constructors, default constructors, parameterized constructors, constructors with default arguments, dynamic initialization of objects, copy constructors, dynamic constructors & destructors, constraints on constructors & destructors. Examples and Exercises. (4L)
Operator overloading overview, defining operator overloading function, Overloading unary operator, binary operators and arithmetic operators, Overloading using friend function, multiple overloading, Overloading comparison operators, conversion between objects and basic types, conversion between objects of different classes, overloading various operators, such as +, -, *, /, =, ==, (), [], {}, &&, ||, ++ (preincrement and post increment) etc. Examples and Exercises. (6L)
Overview, defining derived classes, types of inheritance, single inheritance, making private member inheritable, multilevel inheritance, Multiple inheritance, ambiguity in multiple inheritance Hierarchical inheritance,hybrid inheritance, Virtual base classes, abstract classes, Constructors in derived classes, initialisation list, nesting of classes, Examples and Exercises. (7L)
Overview, late binding, early binding, Pointers to objects, accessing class members using pointers, creating objects at runtime, This pointer, pointers to derived classes, virtual functions, pure virtual functions, Examples and Exercises. (5L)
Overview of Templates, generic class, function template, function template with multiple argument, Class template, Class template with multiple</td></tr>
</table>

	argument, overloading template function, templates as member function of a class, Examples and Exercises. (3L) Exception handling overview, exception handling mechanism, throwing and catching mechanism, Multiple catch, catch All exceptions, rethrowing an exception, Examples and Exercises. (3L) Mini Project Implementation using the concepts. (2L)
Text Books, and/or reference material	**Text Books:** 1. E Balagurusamy, "Object oriented programming in C++", Mc Graw Hill, ISBN 978-93-5260-779-0. 2. Herbert Schildt, "Teach yourself C++", Mc Graw Hill, 3rd Edition, ISBN 0-07-882311-0. 3. Herbert Schildt, "C++: The Complete Reference", Mc Graw Hill, 4th Edition, ISBN 0-07-212124-6. **Reference Books:** 1. Stroustrup, "The C++ Programming Language", 3rd Edition, 2002,Addison Wesley. 2. Eckel, "Thinking in C++", Vol1, 2nd Edition, 2002, Pearson. 3. R. Lafore, "Object Oriented Programming with C++", 4th Edition, 2008, Pearson.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	3	-	2	2	1	-	1	2	1
CO2	3	3	1	3	3	1	-	-	-	1	-	-
CO3	-	3	3	-	3	-	-	-	-	1	1	1
CO4	1	3	2	3	3	1	-	-	-	1	3	1
CO5	1	2	2	3	3	1	-	-	-	1	3	1
CO6	-	-	3	-	3	3	2	-	1	2	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO440	Digital Systems	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT), End Assessment (EA))					
Electronic Devices and Circuits I (ECC302), Basic Electronics (ECC01)		The assessment methods comprise of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.					
Course Outcomes		• **CO1**: Understand rules of Boolean Algebra and use it for logic synthesis. • **CO2**: Design logic circuits using switches, transistors and integrated circuit building blocks. • **CO3**: Understand binary number system and design corresponding arithmetic circuits. • **CO4**: Explain and implement A/D and D/A converters. • **CO5**: Learn sequential circuit building blocks and implement Finite State Machines. • **CO6**: Understand principles of Error Detection and Correction codes.					
Topics Covered		**Module 1: (L- 1)** Introduction: Definition of Analog & Digital information. Characteristics of Digital Circuits. Advantages of Digital systems.					

	Module 2: (L-2) Boolean Algebra: Introduction – rules of Boolean Algebra, axioms, D´Morgan's theorems **Module 3: (L-4)** Logic Gates: Basic Gates, Universal Gates, Realization of logic gates using switches, Transistors (MOS and BJT) as switch. **Module 4: (L-5)** Logic Synthesis: Two level synthesis, SOP/POS forms, canonical forms; Minimization of logical function by - i) Algebraic method, ii)Karnaugh Map method and iii) Quine Mccluskey Method. **Module 5: (L-6)** Combinational Circuits: Multiplexer, Demultiplexer, Decoder, Encoder, decoder driver, designing using these combinational circuits and their applications. **Module 6: (L-4)** Digital Arithmetic: Number systems, Binary arithmetic, Representing negative numbers – sign-magnitude, 1's complement and 2's complement representations; Arithmatic circuits - Half Adder and Full adder Circuits, multi-bit ripple-carry adder and subtractor circuits. Realization of these circuits using Multiplexers. **Module 7: (L- 6)** Sequential Circuits: Definition, Elements of sequential circuits - Latches and Registers, Different kinds of flip-flops – R-S, J-K, Master-slave arrangement, D, and T type registers; Finite state machines - Moore and Mealy machines; Typical sequential circuits -counters, shift registers and sequence generator; synchronous and asynchronous circuits. **Module 8: (L-4)** Multivibrator: Definition of different types of Multivibrators, their realization by logic gates, op-amp and transistors. 555 Timer IC. **Module 9: (L-3)** A/D & D/A Converter: Different types of D/A & A/D Converters. **Module 10: (L- 3)** Codes and Code converters: Gray code, Excess-3 code, BCD Code, BCD to 7-segment decoder: Error Detection and Correction codes - error detection by parity checking, Principle of error correction, Hamming code. **Module 11: (L- 4)** Different logic families such as RTL, DCTL, DTL, HTL, TTL, ECL, MOS & CMOS logic family their importance and applications.
Text Books, and/or reference material	**Text Books**: 1. M. Morris Mano, Digital Design, 3rd Edition, Prentice Hall of India Pvt. Ltd., 2003 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2003. 2. Charles H.Roth. Fundamentals of Logic Design, Thomson Learning, 2004. **Reference Books**: 1. John.M Yarbrough, Digital Logic Applications and Design, Thomson Learning, 2002. 2. William H. Gothmann, Digital Electronics, 2nd Edition, PHI, 1982. 3. Thomas L. Floyd, Digital Fundamentals, 8th Edition, Pearson Education Inc, New Delhi, 2005. 4. Donald D. Givone, Digital Principles and Design, TMH, 2016. 5. John F.Wakerly, Digital Design, Fourth Edition, Pearson/PHI, 2006.

COURSE ARTICULATION MATRIX

PO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	3	2	2	1	-	-	-	-	-	-	3
CO#2	2	3	3	3	2	-	-	-	-	-	-	2

CO#3	2	3	3	3	3	-	-	-	-	-	-	3
CO#4	2	3	3	3	3	-	-	-	-	-	-	2
CO#5	3	3	3	2	3	-	-	-	-	-	-	3
CO#6	1	2	3	1	1	-	-	-	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Electronics and Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO441</td><td>Communication Engineering</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods
Continuous (CT), Mid-Term (MT), End Assessment (EA)</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">The assessment methods comprise of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Identify the methods of communications.
• CO2: Analyze the methods of communications.
• CO3: Apply wired or wireless communication in proper context.
• CO4: Demonstrate the use of communication in different industrial scenarios.
• CO5: Recognize the current technology trends in communication engineering.
• CO6: Design future communication systems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Basics of communication engineering. (2L)
Elements of a communication system; Evolution of communication systems; Challenges and limitations of communication systems; Wired, wireless and storage channels.
Wired communication. (8L)
Telephone: Base and handset, Dialling and signalling, Subscriber loop; Analog and Digital Signals; Sampling: Nyquist’s theorem, Aliasing, Time division multiplexing; PCM: Generation, Regenerative transmission, Detection; Line coding: Types, Criterions for choosing a line code; Fiber optics: Elements, Propagation modes.
Wireless communication. (8L)
Requirement of modulation; Analog modulation: AM, FM; Digital modulation: ASK, PSK, FSK; Cellular: Architecture, Generations; WiFi; Satellite: Kepler’s laws, Components of satellite communication.
Information theory and coding. (8L)
Information: Definition and measurement, Entropy, Information rate; Source coding: Huffman coding, Channel coding: Hamming code, Cryptography: RSA algorithm.
New frontiers in communication. (8L)
Molecular communication; In-vivo communication; Underground communication;
Underwater communication; V2X communication; IoT.
Industrial communication. (8L)
Serial communication, Fieldbus, HART.</td></tr>
</table>

Text Books, and/or reference material	**Text Books**: 1. Communication Systems - A. B. Carlson. **Reference Books**: 1. Communication Systems – S. Haykin. 2. Modern Digital and Analog Communication Systems - B. P. Lathi.

COURSE ARTICULATION MATRIX

PO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	3	2	1	1	1	1	1	1	1	1	1
CO#2	2	3	3	2	1	1	2	1	1	1	1	2
CO#3	3	2	3	2	1	1	2	1	1	1	1	1
CO#4	2	1	1	3	2	3	1	2	1	1	2	1
CO#5	1	1	1	2	1	2	1	1	2	1	2	1
CO#6	1	1	1	1	1	3	2	1	2	2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO440	FUNDAMENTALS OF POWER SYSTEMS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Nil		CT+MT+EA					
Course Outcomes	• CO1: Given Specification leads to design of network, choice of optimal Voltage, Transmission line and its material. • CO2: Given Specification leads to study of suitable system parameters and in corporation laws of Power systems to choose the most applicable. • CO3: Given Specification emphasizes on the different Tariff structures, by which one can able to judge, compare and select a suitable Tariff plan. • CO4: Given Specification facilitates the design of equipment's on the basis of power factor. • CO5: Given specification will give knowledge about the different types of faults and its severity, which can help to design the protection schemes for those faults.						
Topics Covered	Power System Network: Single phase transmission, three phase transmission, complex power, Basic Structure of power system, overhead and underground systems, overhead line conductors, Transmission, and distribution systems in India. (2) Generating Stations: Steam Power station, Hydro-electric power station, Gas turbine power station, nuclear power station, classification, Comparison of various power stations. (5) Supply Systems: AC power supply scheme, Comparison of DC and AC transmission, Advantages of High transmission voltage, various systems of						

	power transmission, comparison of conductor material in overhead system, comparison of conductor material in underground system, Choice of transmission voltage. (5) Line Parameters and Performance of Transmission Lines: Line resistance, Inductance, Capacitance, Representation of Lines, per unit method, advantages of per unit systems, short transmission line, medium length transmission line, long transmission line, Evaluation of ABCD parameter, equivalent pi and T circuit. (8) Conductors: Introduction, Type of Conductor, Skin effect, Kelvin's economy law, modified Kelvin's law, Limitations of Kelvin's law (4) Overhead Line Insulators: Type of insulator, voltage distribution over insulator string. (3) Tariffs: Introduction, Types of Tariff-Flat demand tariff, straight line meter rate tariff, Block meter type tariff, Two-part tariff, Power factor tariff, Peak load tariff, three-part tariff (3) Power Factor Improvement: Introduction, Disadvantages of low power factor, causes of low power factor, power factor improvement, power factor correction by static capacitor. Economics of power factor improvement. (5) Power Systems Fault and Protection: Symmetrical components, Symmetrical faults and unsymmetrical faults, Switches, fuses, circuit breakers, protective systems, protective relays, (5) Power System Earthing: Type and methods of earthing, earth resistance, Design of Earthing grid, Tower footing resistance, measurement of earth resistance, neutral grounding. (2)
Textbooks, and/or reference material	Textbooks: 1. H. Cotton & H. Barber, The Transmission and Distribution of Electrical Energy, Hodder Arnold 2. A. R. Bergen, V. Vittal, Power Systems Analysis, Pearson Edition Reference Books: 1. John J. Grainger & William D. Stevenson, Power system analysis, Tata McGraw Hill Education. 2. D. P. Kothari & I. J. Nagrath, Power System Analysis, Tata McGraw Hill

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	2	1	1	1		1			1
CO2	3	3	2	1	1	1			1			
CO3	3	1	3	1	2	3		1				2
CO4	3	3	2	1	2	2	1		1			1
CO5	3	3	2	1	2	1	1	1	1		1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="7">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEO441</td><td>CONCEPT OF INDUSTRIAL ELECTRONICS</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">ECC 331 (ANALOG ELECTRONICS), EEC 403(DIGITAL ELECTRONICS)</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• CO 1: Acquire an idea about semiconductor devices
• CO2: To learn the basic operation of the ac-dc/ dc-dc/ dc-ac/ ac-ac components
• CO3: To identify the application of the components in different fields of Engineering
• CO4: To identify the utilisation of the components in Industry</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Review of Power Electronic Systems: Overview of Some Modern Power Semiconductor Devices. (2)
Digital Electronics: Overview, Number Systems, Integrated Circuits, Logic Families, Pin Identification. (6)
Uncontrolled rectifiers: Single phase and multiphase different circuit arrangements and their operation, analysis, performance evaluations. (6)
Controlled rectifier: Semi Controlled and fully controlled converters, single phase and multiphase, different circuit arrangements and their operation analysis performance evaluations. (6)
DC-DC Converters: Classification, principles of operation, step down (Buck) and step up (Boost) switched mode power supply, Buck-Boost Converter. (6)
Inverters: Classification, theory of operation, square wave Inverter, PWM switching topology, performance evaluation, applications. (6)
Applications: DC Drives, AC Drives, Power Conditioners and Uninterruptible Power Supplies, Power Line Disturbances, Power Conditioners, UPS. (6)
Other Residential and Industrial Applications. (4)</td></tr>
<tr><td>Textbooks, and/or reference material</td><td colspan="6">Textbooks:
1. B. K. Bose, Power Electronics and AC Drives, Prentice- Hall
2. N. Mohan, T. M. Underland & Riobbins, Power Electronics: Converters, Applications & Design, John-Wiley.
Reference Books:
1. L. Umanand, Power Electronics, Essentials & Applications, Wiley India Pvt. Ltd</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1	PO12
CO1	3	3	3	3	3	3	3	2	2	2	1	3
CO2	3	3	3	3	3	3	3	2	2	1	2	2
CO3	3	3	3	3	3	3	3	2	2	1	2	2
CO4	3	3	3	3	3	3	3	2	2	1	2	2
CO5	3	3	3	3	3	3	3	2	2	2	1	3
CO6	3	3	3	3	3	3	3	2	2	1	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEO442</td><td>ENERGY CONSERVATION, AUDIT AND ICT & IOT APPLICATION FOR MONITORING</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC01 (ELECTRICAL TECHNOLOGY)</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO 1: To understand the Overall Energy Scenario (National & International
• CO2: To build the skill in Energy management
• CO3: To be able to conduct the energy audit.
• CO4: To understand the energy saving
• CO5 :To understand the energy monitoring through ICT & IoT</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Overall understanding Energy Scenario National and International perspective, Energy system as electrical system, Energy chain, National and International Energy scenario, various non-conventional energy resources-importance, classification, relative merits and demerits, Carbon emission, carbon credit, International environmental meet for awareness of Green House emission (GHG). (10)
Definition and Objective of Energy Management, General Principles of Energy Management, Energy Management Skills, Energy Management Strategy. (6)
Energy Audit: Need, Types, Methodology and Approach. Energy Management Approach, Understanding Energy Costs, Energy performance, Matching energy usage to requirements, maximizing system efficiency, Optimizing the input energy requirements, Fuel and Energy substitution. (6)
Procedures and Techniques for Energy Audit, Data gathering: Level of responsibilities, energy sources, control of energy and uses of energy get Facts, figures and impression about energy /fuel and system operations, Past and Present operating data, Special tests, Questionnaire for data gathering. Analytical Techniques: Incremental cost concept, mass and energy balancing techniques, inventory of Energy inputs and rejections, Heat transfer calculations, Evaluation of Electric load characteristics, process and energy system simulation. (8)
Evaluation of saving opportunities: Determining the savings in Rs, Noneconomic factors, Conservation opportunities, estimating cost of implementation. Energy Audit Reporting: The plant energy study report-Importance, contents, effective organization, report writing and presentation. (6)
Basics of Information Communication Technology (ICT), Internet of Things (IoT). Basic sensors for Energy Monitoring and Evaluation, Application of ICT and IoT for energy monitoring. Remote supervision of Energy use. (6)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
1. Energy for a sustainable world: Jose Goldenberg, Thomas Johansson, A.K.N.Reddy, Robert Williams (Wiley Eastern).
2. Energy policy for: B.V. Desai (Weiley Eastern),
3. Modeling approach to long term demand and energy implication: J.K.Parikh.
4. Energy Policy and Planning: B.Bukhootsow</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	1	3	2	2	1	2	1	3	2
CO2	2	2	1	1	2	1	2	3	1	1	2	2
CO3	2	2	1	1	3	1	2	2	1	2	1	2
CO4	1	3	1	3	2	1	3	1	1	2	2	1
CO5	2	3	1	1	2	2	3	2	2	2	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEO443</td><td>NETWORK THEORY</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MAC02(MATHEMATICS -II), EEC01 (ELECTRICAL TECHNOLOGY)</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Apply the knowledge of basic circuital law, like nodal analysis and mesh analysis, to write the equations for large linear and coupled circuits.
• CO2: Apply Thevenin’s and Norton’s theorems to 12nalyse and design for maximum power transfer.
• CO3: Apply the Laplace transform to linear circuits and systems and 12nalyse the signal synthesis.
• CO4: Evaluate the performance of RL, RC, and RLC circuits by the application of Laplace transform.
• CO5: Analyze the given network using graph theory technique.
• CO6: Analyze the given network using different two port network parameters.
• CO7: Determine the response of a network using the network function and draw pole-zero plots, Bode plot etc.
• CO8: They will also be able to synthesize the network functions.
• CO9: Students should be able to design the passive filters.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to circuit variables and circuit elements, Review of Kirchhoff s Laws, Independent and dependent Sources, Source Transformations. Solution methods applied to dc and phasor circuits: Mesh and node analysis of network containing independent and dependent sources Network topology, Network graphs, Trees, Incidence matrix, Tie-set matrix and Cut-set matrix. (8)
Network theorems applied to dc and phasor circuits: Thevenin’s theorem, Norton’s theorem, Superposition theorem, Reciprocity theorem, Millman’s theorem, Maximum power transfer theorem. (6)
Laplace transform, properties Laplace Transforms and inverse Laplace transform of common functions, Important theorems: Time shifting theorem, Frequency shifting theorem, Time differentiation theorem, Time integration theorem, s domain differentiation theorem, s domain integration theorem, Initial value theorem, Final value theorem Partial Fraction expansions for inverse Laplace transforms, Solution of differential equations using Laplace transforms</td></tr>
</table>

	Transformation of basic signals and circuit into s- domain Transient analysis of RL, RC, and RLC networks with impulse, step, pulse, exponential and sinusoidal inputs. (8) Two-Port parameters: Open circuit, short circuit, transmission and hybrid parameters, relationship between parameter sets, reciprocity and symmetry conditions, parallel connections, parallel connection of two port networks. Network equivalents - Analysis of T, n, ladder, and lattice networks. (8) Network functions for the single port and two ports, properties of driving point and transfer functions, Poles and Zeros of network functions, Significance of Poles and Zeros. Time domain response from pole zero plot, Impulse Response Network functions in the sinusoidal steady state, Magnitude and Phase response. (5) Resonance: Series resonance, bandwidth, Q factor and Selectivity, Parallel resonance. Coupled circuits: single tuned and double tuned circuits, dot convention, coefficient of coupling, Analysis of coupled circuits. (7)
Text Books, and/or reference material	Text Books: 1. Kuo Franklin F., Network analysis and synthesis, 1st ed., Wiley International, 1962. 2. Van Valkenburg M.E., Network analysis, 3rd ed., Eastern Economy Edition, 1983. Reference Books: 1. Roy Chaudhary D., Network and systems, Wiley Eastern Limited. 2. Chattopadhyay D &Rakshit P C-Fundamental of Electric Circuit Theory-S chand& company Ltd. Edminister Joseph A., NahviMohmood, Electric Circuits, 3rd ed., Tata McGraw Hill.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	1	2	1	3	3	3	2
CO2	3	3	2	3	3	1	2	1	3	3	3	2
CO3	3	3	2	3	3	1	2	1	3	3	2	3
CO4	3	3	2	3	3	1	2	1	3	3	2	3
CO5	3	3	1	1	1	1	1	1	2	3	1	2
CO6	3	3	1	3	3	1	1	1	3	3	1	2
CO7	3	3	3	3	3	1	3	1	3	3	3	2
CO8	3	3	3	1	1	1	3	1	3	3	3	2
CO9	3	3	3	1	1	1	3	1	3	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XEO441	Brain to Mind Creation	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC01: Life Science		CT+MT+EA					
Course Outcomes	• CO1: Understanding Cognitive Science and the Processes • CO2: Understanding the Physics and Electrochemical Reactions in Brain.						

	• CO3 : Understanding the Behavioral Pattern of a Human Being
Topics Covered	Brain to Mind-- and how do we know it---(essentially single neuron to multiple). (4) Brain and gross specialization --- areas , right-left , association ,connectivity and our tools to learn including EEG (6) Being Conscious -- Dynamics --- how do we learn about it from EEG (8) Cognition, Memory, Emotion -- Normal and Pathology. (6) Sleep and neural network (4) Brain and Future-- with interactive session (2)
Text Books, and/or reference material	Suggested Text Books: 1) Biological basis of Behavior- Prof. Braj Bhushan 2) A Beautiful Mind - Dr. Alok Bajpai 3) Cognition, Brain, and Consciousness: Introduction to Cognitive Neuroscience, 2nd Edition by Bernard J. Baars (Author), Suggested Reference Books: Principles of Neural Science, Fifth Edition by Eric R. Kandel and James H. Schwartz

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	1	1	1	1	1	1	1	1
CO3	3	3	3	3	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

BASKET – 2

<table>
<tr><td colspan="8">Department of Humanities and Social Sciences</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>HSO 540</td><td>Entrepreneurship Development: Theory and Practice</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">The students develop and can systematically apply an entrepreneurial way of thinking that will allow them to identify and create business opportunities that may be commercialized successfully.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">• Unit 1: Entrepreneur: Definition (3L)
• Unit 2: Entrepreneur: Theory (3L)
• Unit 3: Entrepreneurship: Success Story (3L)
• Unit 4: Factors Affecting Entrepreneurial Growth (3L)
• Unit 5: Entrepreneurial Motivation (3L)
• Unit 6: Creativity (3L)
• Unit 7: Financing of Enterprises (3L)
• Unit 8: Forms of Business Ownership (3L)
• Unit 9: Business Plan I (3L)
• Unit 10: Business Plan II (3L)
• Unit 11: Project Appraisal I (3L)
• Unit 12: Project Appraisal II (3L)
• Unit 13: Entrepreneurship Practice I (3L)
• Unit 14: Entrepreneurship Practice II (3L)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">TEXT BOOKS:
1. Donald F. Kuratko. Entrepreneurship: Theory, Process, and Practice ,Cengage Learning, 2008
2. Robert Baron&Scott Shane. Entrepreneurship: A Process Perspective,Cengage Learning, 2007
REFERENCE BOOKS:
1.S. S. Khanka. Entrepreneurial Development, S. Chand Limited, 2006.
2.GeorgeVozikis, Timothy Mescon, Howard Feldman & Eric W Liguori. Entrepreneurship: Venture Initiation, Management and Development,Routledge, 2013.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	3	3	3	2	3	3	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Humanities and Social Sciences</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>HSO541</td><td>Statistical Techniques for Economics</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">CO1: Develop an understanding about the basic concepts of Statistics.
CO2: To be able to apply various statistical tools in analysing fundamental economic problems.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">• Unit 1: Nature of Statistical Data and its Presentation (2)
• Unit 2: Measures of Central Tendency (3)
• Unit 3: Measures of Dispersion (3)
• Unit 4: Moments, Skewness and Kurtosis (3)
• Unit 5: Bivariate Data Analysis: Correlation & Regression (3)
• Unit 6: Time Series (4)
• Unit 7: Set Theory (3)
• Unit 8: Theory of Probability, Random Variables and Expectation (5)
• Unit 9: Univariate Probability Distributions (4)
• Unit 10: Sampling Theory and Distributions (4)
• Unit 11: Theory of Estimation (4)
• Unit 12: Theory of Testing of Hypothesis (4)</td></tr>
<tr><td colspan="2">Text Books, and/or reference material</td><td colspan="6"><u>Text Books</u>
• Goon, Gupta and Dasgupta – Fundamental of Statistics, Vol. I & II, World Press Private Ltd, 2013, 2016.
• Gupta and Kapoor – Fundamental of Mathematical Statistics.S.Chand & Sons, 2014.
<u>Reference Books</u>
• A. M. Mathai&P. N. Rathie – Probability and Statistics. Palgrave MacMillan. 2014.
• William G. Cochran - Sampling Techniques. Wiley& Sons. 2007.
• Sheldon Ross- A First Course in Probability. Pearson Education India. 2013.
• D. R. Agarwal – Comprehensive Statistics. Vrinda Publications (p) Ltd. 2011.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	1	-	-	-	2	-
CO2	1	-	-	3	2	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO543	Personality Development	PEL	42	0	0	42	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: To develop the all-round personality of students • CO2: To make students confident enough to face any situation with optimistic zeal.						
Topics Covered	Personality: Meaning and Possibilities. (2) Characteristics of a healthy personality. (4) Grooming and blooming personality: Critical approaches. (6) Self and the other: balancing the binaries (8) Communication Skills: verbal and non-verbal. (10) Behavioural health and wellness. (8) Decision and implementation: measures and challenges. (4)						
Text Books, and/or reference material	Suggested Text Books: 1. Carnegie, Dale. *How to Win Friends and Influence People*. Amazing Reads, 2016. 2. Peale, Norman Vincent. *The Power of Positive Thinking*. RHUK, 2016. Suggested Reference Books: 1. Csikszentmihalyi, Mihaly. *Flow: The Psychology of Optimal Experience*. Harper Perennial Modern Classics, 2018. 2. Canfield, Jack et al. *Chicken Soup for the Unsinkable Soul*. Backlist LLC, 2012.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
CO1	-	2	-	2	-	3	3	2	3	3	-	2
CO2	-	3	-	2	-	3	2	2	3	3	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Humanities & Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO544	Soft Skills	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	• CO1: Learners will have a good grasp of soft skills in its different variants • CO2: Learners will be better equipped to showcase and share their knowledge and skills • CO3: Learners will be better prepared for employment opportunities and career growth
Topics Covered	1. Concept of Soft Skills (4) 2. Personality Traits (4) 3. Confidence Building (4) 4. Workplace Communication (4) 5. Employability (4) 6. Facing Interview (4) 7. Team Spirit (4) 8. Motivational Leadership (5) 9. Workplace Etiquette (4) 10. Intercultural Soft Skills (5)
Text Books, and/or reference material	Suggested Text Books: 1. *Soft Skills & Employability Skills*. Sabina Pillai & Agna Fernandez. Cambridge University Press. 2. *Soft Skills*. K. Alex. S. Chand Suggested Reference Books: 1. *You Can Win*. Shiv Khera. Penguin.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	3	-	3	-	3	-	3
CO2	1	2	2	2	2	-	3	-	3	-	1	3
CO3	-	-	-	-	-	3	3	3	3	-	-	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAO541	Mathematical methods for engineers	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-term assessment (MA) and end assessment (EA))					
MAC02 (Mathematics-II)		CT+EA					
Course Outcomes	• CO1: Students will be able to understand and solve the difference equations that are used to model various engineering problems. • CO2: To enable the students to apply integral transforms to problems formulated on finite or infinite domains and also to solve engineering and physical problems involving PDEs in a simpler way using integral transforms. • CO3: To enable the students to solve a discrete systems using Z-Transform.						

	• CO4: Students will have an in-depth knowledge of power series solution of differential equations and also will learn about special functions which arise in many engineering and physical problems.
Topics Covered	**Difference Equations:** Formation of difference equation, First and higher order difference equations, Reduction of non-linear difference equation into linear form, Solution of difference equations. (6) **Z-transform:** Some standard Z- transforms, Properties of Z-transform, Damping rule, Shifting rule, Initial and final value theorem, Convolution theorem, Inverse Z-transform, Solution of difference equations using Z-transform. (6) **Series Solution of Ordinary Differential Equations:** Validity of series solution, Series solution about an ordinary point and about a regular singular point, Bessel's equation and Bessel functions, Recurrence relations of Bessel functions, Generating function for $J_n(x)$, Orthogonality of Bessel functions, Legendre's equation and Legendre functions, Legendre polynomial, Rodrigue's formula, Generating function for $P_n(x)$, Recurrence relations for $P_n(x)$, Orthogonality of Legendre polynomial. (15) **Application of Fourier Transforms:** recapitulation of Fourier transform & its properties, solution of partial differential equations using Fourier transform (6) **Application of Fourier Transforms in mathematical statistics (2)** **Finite Fourier Transforms:** Finite Fourier Sine & Cosine transform, basic properties, applications of finite Fourier Sine & Cosine transform in the solution of boundary value problems (7)
Text Books, and/or reference material	**Text Books:** 1. S. L. Ross: Differential Equations: John Willey and Sons. 2. I. N. Sneddon: The use of Integral Transforms, McGraw-Hill, 1974. 3. E. Kreyszig: Advanced Engineering Mathematics: 10th edition, Wiley India Edition (2010). **Reference Books:** 1. M.D. Raisinghania: Advanced differential equations: S. Chand Publication. 2. L. Debnath & D. Bhatta: Integral Transforms and their applications: 2nd Edition, Chapman & Hall/CRC.

Course	COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
MAO541	CO1	3	3	3	2	1	1	1	-	1	1	-	2
	CO2	3	3	2	2	1	1	1	-	1	1	-	2
	CO3	3	2	2	2	2	1	1	-	1	1	-	3
	CO4	3	2	2	2	2	1	1	-	1	1	1	3

Department of mathematics						
Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
		Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
Linear Algebra	PEL	3	0	0	3	3
Pre-requisites	MAC02					
Course Assessment methods (Continuous (CT) and end assessment (EA))	CT+EA					
Course Outcomes	• CO1: Solve systems of linear equations using several methods, including Gaussian elimination and matrix inversion					

	• CO2: Demonstrate understanding of the concepts of vector space and subspace, linear independence, span, and basis and use these for analysis of matrices and systems of linear equations. • CO3: Determine eigenvalues and eigenvectors and solve eigenvalue problems; apply principles of matrix algebra to linear transformations; discriminate between diagonalizable and non-diagonalizable matrices; demonstrate understanding of inner products and associated norms.
Topics Covered	• Systems of linear equations, Matrices, Elementary row and column operations, Row-reduced echelon matrices. Gaussian elimination, LU-Decomposition. (6) • Vector spaces, Subspaces, Linear span, Linear dependence and independence, Basis and dimension, ordered basis and coordinates, Row space and column space, Direct-sum decompositions. (12) • Linear transformations, Rank-Nullity theorem, Matrix representation of linear transformations. (7) • Eigenvalues and eigenvectors, Cayley-Hamilton theorem, Diagonalization of Matrices, Minimal polynomial, rational canonical form, Jordan canonical form. (13) • Inner Product Spaces, Orthonormal Basis, Gram-Schmidt Theorem. (4)
Text Books, and/or reference material	**Text Books:** 1. K. Hoffman and R. Kunze, Linear Algebra, Prentice Hall of India, New Delhi, 1990. 2. S. K. Mapa, Higher Algebra, Sarat Book Distribution, 2000. **Reference Books:** 1. S. Lang, Linear Algebra, Springer, Third Edition. 2. S. Kumaresan, Linear Algebra: A Geometric Approach, PHI Learning Pvt. Ltd., 2000.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
MAO542	CO1	3	2	1	-	1	-	1	1	-	-	-	2
	CO2	3	3	1	1	1	-	1	-	-	-	-	2
	CO3	3	3	2	1	1	1	1	-	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAO543	Modern Algebra	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Acquire an idea about abstract mathematical problems • CO2: To understand the principle of symmetric objects • CO3: To learn the basic tools of vector spaces, coding theory and						

	cryptography
Topics Covered	Preliminary concept: Sets and Equivalence relations and partitions, Division algorithm for integers, primes, unique factorizations, Chinese Remainder Theorem, Euler ϕ-function. [10] Groups: Cyclic groups, Permutation groups, Isomorphism of groups, Cosets and Lagrange's Theorem, Normal subgroups, Quotient groups, Group homomorphisms, Cayley's theorem, Cauchy's theorem. [12] Rings: Ideals and Homomorphism, Prime and Maximal Ideals, Quotient Field of an Integral Domain, Polynomial Rings. [10] Fields: Vector space, Field extensions, Finite Fields. [10]
Text Books, and/or reference material	**Text Books:** 1. *J. B. Fraleigh, A First Course in Abstract Algebra*, Addison Wesley, 2013. 2. *I. N. Herstein, Topics in Abstract Algebra,* Wiley Eastern Limited, 1975. **Reference Books:** 1. *T. W. Hungerford, Algebra, Springer*, 2009. **2.** *D. S. Dummit, R. M. Foote, Abstract Algebra*, Second Edition, John Wiley & Sons, Inc., 1999. **3.** *G. A. Gallian, Contemporary Abstract Algebra*, Narosa Publishers, 2017.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO 1	PO 2	PO 3	PO4	PO5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
MAO5 43	CO1	3	3	2	2	1	-	1	1	-	-	1	1
	CO2	3	3	1	1	1	1	1	-	-	-	-	-
	CO3	3	2	1	3	2	-	-	-	1	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHO541	**Thin Film Technology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes		CO1: To understand growth mechanism of thin film CO2: To comprehend application of thin film in modern devices CO3: To be familiar with characterization technique of thin film CO4: To know about the industrial applications of thin film					
Topics Covered		**Introduction:** Basic of Thin films and Nanostructures, Role of thin films in Devices. [2] **Nucleation, film growth and structure**: Thermodynamics of Nucleation, Nucleation theory: Capillarity Model and Statistical Model, Comparison of two models, Film growth: Volmer-Waber growth, Frank-Vander-Merwe and Stranski-Krastonav growth, Dissociations, Doping and diffusion effects, Film thickness. [9] **Deposition Technique**: Thermal Evaporation: Resistive heating, Flash evaporation, Arc evaporation, Laser evaporation, rf heating, Electron bombardment heating, Sputtering: Glow discharge sputtering, Low pressure sputtering, Reactive sputtering, rf sputtering,					

	Chemical Methods: Electro-deposition, Electrolytic deposition, Chemical Vapour deposition, Liquid phase epitaxy, Molecular beam epitaxy, Spin coating, Sol gel, Langmuir Blodgett (LB) Techniques. [12] **Thin Film Characterization:** X-ray diffraction and G-XRD method, Atomic force microscope (AFM) method for determination of surface roughness, Scanning tunneling microscopy (STM), Thickness measurement techniques (ellipsometer), Field emission scanning electron microscopy (FESEM), Transmission electron microscopy (TEM), Hall effect, UV-vis spectroscopy, photo luminance process, Schottky contact, Ohmic contact, Photocurrent and photocapacitance measurement. [12] **Thin film Devices:** Applications of different thin films in modern technology, Photo diode, LED and Solar cell. [7]
Text Books, and/or reference material	**TEXT BOOKS:** 1. Thin Film Phenomena, K. L. Chopra 2. An Introduction to Physics and Technology of Thin Films, Part – I & II, A. Wagendristel & Y. Wang. 3. Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley, Mark Geoghegan **REFERENCE BOOKS:** 1. Thin Film Fundamentals, A. Goswami 2. Handbook of Thin Film Technology, Maissel and Glange 3. Thin Film Solar Cells, S. R. Das and S. P. Singh

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
PHO 541	CO1	3	1	2	3	1			1				1
	CO2	3	3	2	2			2	1				1
	CO3	3	2	2	2	1	1	1	1	1	1	1	1
	CO4	3	2	2	2	1	1	1	2	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO540	Mineral Biotechnology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: To understand the nature and characteristics of different biogeochemical cycles and involvement important micro-organisms. • CO2: To learn the basic concepts of bioleaching and bio-beneficiation along with the microbiological aspects • CO3: To gain the detail knowledge bioleaching processes with						

	examples. • CO4: To demonstrate and provide examples on how to use microbes for the environmental pollution control
Topics Covered	**Module-I :** Introduction to Biotechnology applied to Raw Material processing, Biogeochemical reactions – chemical mechanisms and controlling factors, Microbial interventions, Nature and characteristics of Biogeochemically important micro-organisms. 10 **Module-II:** Kinetics of bioleaching; Applications of biogeochemical process in mining and metallurgy, dump, heap and in-situ leaching. 8 **Module-III:** Reactor modeling for leaching, Beneficiation of ored and process residues: recovery of gold, silver, copper, beneficiation of sulfidic tailings from tin processing; purification of ferroginous sand. 8 **Module-IV :** Beneficiation of bauxite, applications of sulphate reducing bacteria; applications of sulphate reducing bacteria, Environmental pollution control: accumulation of metals by microbial cells. 8
Text Books, and/or reference material	Suggested Text Books: 1. H.D. Kumar and S.Kumar , Modern Concepts of Microbiology , Vikas Publishing House , 2nd Edition , 2001 2. M.E. Curtin , Microbial mining and metal recovery biotechnology (1) , pp 229-235 , 1983 Suggested Reference Books: 1. Woods D, Rawling D.E., Bacterial bleaching and biomining J.L.(ed), Revolution in biotechnology , Cambridge University Press.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	-	2	1	1	-	1	-	-	1
CO2	2	1	1	-	1	-	2	1	1	1	-	1
CO3	2	1	1	1	1	-	1	-	1	-	-	1
CO4	2	1	1	1	1	-	2	1	1	1	1	1

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR)/ Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTO541</td><td>Introduction to Computational Biology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Life Science BTC01</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">· CO1: To impart knowledge of life science and biological data
· CO2: To acquire knowledge of computational and mathematical skills for addressing important biological questions.
• CO3: To learn how to develop and implement computational algorithms and tools for processing biological data</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Introduction to Computational biology and its applications(2)
2. Central dogma and biological macromolecules- DNA, RNA & proteins(2)
3. Major biological databases related to DNA, RNA, proteins & metabolic pathways(3)
4. Basic file formats & sequence representation(2)
5. Computational algorithms for Sequence Alignment: Local and global alignment, Sequence similarity, Sequence identity, Gaps, Scoring matrices, pairwise and multiple alignments, Dynamic programming, BLAST & its application,(7)
6. Algorithms for phylogenetics: Tree constructions(5)
7. Structural Bioinformatics:
· Protein Structure and its visualization(2)
· Protein structural alignment(3)
· Protein secondary Structure Prediction(4)
· Protein tertiary Structure Prediction(4)
· RNA Structure Prediction(3)
· Molecular docking and docking algorithms(3)
8. Application of machine learning in biological sciences (Basic concepts) (2)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
1. Bioinformatics: Sequence and Genome Analysis by David W Mount, Cold Spring Harbor LaboratoryPress
2. Introduction to Bioinformatics by Arthur MLesk
<u>Suggested Reference Books:</u>
1. Protein bioinformatics: an algorithmic approach to sequence and structure analysis by Ingvar Eidhammer, IngeJonassen and William R.Taylor.
2. Essentials of Bioinformatics by JinXiong</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1			1	1			1			
CO2	3	3	2		2	1			2			
CO3	3	3	2	2	3	1		1	3	1	2	1

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO540	**Numerical methods in Engineering**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Engineering Mathematics		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	· CO1: Assess the error involved in a numerical method · CO2: Solve problems in engineering and science with a required accuracy using appropriate numerical methods · CO3: Write algorithm for the numerical methods for efficient coding of program · CO4:Understand the mathematics concepts underlying the numerical methods						
Topics Covered (Hrs)	**Fundamentals of numerical methods:** Need for Numerical methods in Civil Engineering, Sources of Errors, Absolute, Relative and Percentage, round off error, and stability of algorithms. **(4)** **Linear system of algebraic equations:** Gauss elimination method, LU decomposition method; iterative methods, ill conditioned systems. Jacobi, Gauss Seidel method, Relaxation method. **(8)** **Nonlinear equations:** Bisection method, Regula Falsi method, Newton Raphson method, Modified Newton-Raphson method, Higher order Newton's method Bairstow method, system of non-linear equations. **(8)** **Interpolation and approximation**: Newton's, Lagrange and Hermite interpolating polynomials, cubic splines; least square and minimax approximations**. (6)** **Numerical differentiation and integration:** Newton-Cotes and Gaussian type quadrature methods. **(6)** **Ordinary differential equations:** Initial value problems: single step and multistep methods, stability and their convergence. Boundary value problems: functional approximation, finite difference method. **(8)**						

Text Books, and/or reference material(s)	***Text Books:*** 1. Numerical Methods for Scientists and Engineers by R. W. Hamming, Dover Publications; 2 edition 2. Numerical Methods: Problems and Solutions by Mahinder Kumar Jain (Author), S.R.K. Iyengar (Author), R. K. Jain, New age publishers 3. Numerical Methods for Engineers by Chapra, S. C., and Canale, R. P., McGraw Hill, Inc., 2007. ***Reference Books:*** 4. Applied Numerical Methods for Engineers Using Matlab and C by Robert J. Schilling (Author), Sandra L. Harris, Nelson Engineering; Har/Cdr edition 5. Numerical Analysis for Scientists and Engineers: Theory and C Programs by Madhumangal Pal, Alpha Science Intl Ltd; 1 edition

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO 5	PO6	PO7	PO 8	PO9	PO10	PO11	PO 12
CO1	2	-	-	-	-	-	-	-	-	-	-	-
CO2	3	-	3	-	3	-	-	-	-	-	-	-
CO3	3	-	3	-	3	-	-	-	-	1	-	-
CO4	2	-	-	-	3	-	1	-	-	-	-	-

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO541	**Engineering Computing & Simulation with Scilab**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Engineering Mathematics		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	· CO1: Understand the basic elements of scilab language. · CO2: Compute different mathematic operations like scalars, vectors, matrix, statistics and probability, ordinary differential equations by using scilab. · CO3: Use modern software tools scilab. · CO4: Use scilab to simulate the different engineering problems.						
Topics Covered (Hrs)	**Introduction:** Introduction to scilab, scilab environment, workspace, working directory. **(2)** **Basic elements of the language:** Basic elements of the scilab language. **(2)** **Basic mathematical operations or functions:** Scalars & vectors, matrix operations, ordinary differential equations, statistics, probability functions using scilab. **(10)** **Plotting with scilab:** Plotting 2D and 3D graphs using scilab**. (4)** **Simulation techniques:** Monte Carlo method, Latin Hypercube simulation,						

	Variation reduction techniques. **(10)** **Scilab functions:** script files and functions files, different functions in scilab. **(6)** **Applications:** Programming with scilab and solve different engineering problems. **(6)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Engineering and Scientific Computing with Scilab by C. Bunks, J. P Chancelier, F. Delebecque, C. Gomez, M. Goursat, R. Nikoukhah, and S. Steer., Birkhäuser; 1999. 2. Modelling and Simulation in Scilab/Scicos by Stephen L. Campbell, Jean-Philippe Chancelier, and Ramine Nikoukhah, Springer. 2010. 3. A Practical Introduction to Programming and Problem Solving by Tejas Sheth, Scilab, Create Space Independent Publishing Platform, 2016. ***Reference Books:*** 4. Scilab by Example by M. Allouf, Create Space Independent Publishing Platform, 2012.

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO 5	PO6	PO7	PO 8	PO9	PO10	PO11	PO1 2
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	1	2	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	3	-	-	-	-	-	-	-
CO4	-	1	2	2	-	-	-	-	-	-	-	-

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO542	**Introduction to Random Vibrations**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Basic Engineering vibrations, statistics and probability		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	· CO1: Development of skills for predicting engineering system behaviour under random vibrations · CO2: Knowledge of basics of random vibration analysis for further applications. · CO3: Developing the requisite skill that helps in the advanced courses related to random vibration study.						

Topics Covered (Hrs)	**Review** of basic topics in probability theory and vibrations **(4)** **Introduction** to the theory of random processes Time- and frequency-domain characteristics Stationary and nonstationary processes Continuity, differentiation and integration, Poisson, Gaussian processes. **(10)** **Random vibration** of linear structures Unit-impulse and frequency-response functions Time- and frequency-domain analysis Single- and multi-degree-of-freedom systems Stationary and nonstationary responses State-space formulation Modal cross-correlations Response to multi-support excitation, coherency function **(12)** **Crossings and reliability** analysis Threshold Crossings The envelope process First passage probability Distribution of local and extreme peaks **(8)** **Response spectrum** methods Response spectrum methods (CQC, CQC3, MSRS) PSD consistent with response spectrum**. (8)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Probabilistic Theory of Structural Dynamics by Y. K. Lin, McGraw-Hill, New York, NY, 1967 Krieger Pub., Huntington, NY, 1976. **2.** Probabilistic Structural Dynamics: Advanced Theory and Applications by Y. K. Lin and G.Q. Cai, McGraw-Hill, New York, NY, 1995. ***Reference Books:*** 3. An Introduction to Random Vibrations, Spectral & Wavelet Analysis: Third Edition by D.E. Newland, Dover Publications, Mineola, NY, 2005. 4. Introduction to Random Vibrations by N. C. Nigam, MIT Press, Cambridge, MA, 1983. 5. Applications of Random Vibrations by N.C. Nigam and S. Narayanan, Narosa Pub., New Delhi,India, 1994.

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO9	PO10	PO11	PO1 2
CO1	-	-	-	2	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	1	-	-	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit (C)
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CHO 541	**SOLID & HAZARDOUS WASTE MANAGEMENT WITH A HOLISTIC APPROACH**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Environmental Science		CT+MT+EA					
Course Outcomes	• CO1: Become aware of environment and health impacts of solid & hazardous waste & knowledge of legal aspects of management of solid & hazardous wastes.						

	• CO2: Identify improper practices of solid & hazardous waste disposal and their environmental implications. Know the basic engineering principles of solid & hazardous waste management • CO3: Conceive the design aspects of engineered disposal options and apply the gained knowledge to solve numerical examples.
Topics Covered	**Module I:** Air Pollution: Sources, Health Hazards, global warming & climate change. Introduction to water pollution Introduction on sustainable development goal (SDG). Nature as a collection of Units, Classification of Units into four orders, Interconnectedness and mutual fulfilment among the four orders, Dependence of the human being on the other three orders, my participation in nature, vision for holistic technologies, production system and management models. Relevant Regulations of waste management Municipal solid waste (management and handling) rules; hazardous waste (management and handling) rules; biomedical waste handling rules; flyash rules; recycled plastics usage rules; batteries (management and handling) rules. [14 hrs.] **Module II:** Municipal Solid Waste Management – Fundamentals Sources; composition; generation rates; collection of waste; separation, transfer and transport of waste; treatment and disposal options Hazardous Waste Management – Fundamentals Characterization of waste; compatibility and flammability of chemicals; fate and transport of chemicals; health effects Physicochemical Treatment of Solid and Hazardous Waste *Chemical treatment* processes for MSW (combustion, stabilization and solidification of hazardous wastes); *physicochemical* processes for hazardous wastes (soil vapor extraction, air stripping, chemical oxidation); ground water contamination and remediation. [14 hrs.] **Module III:** Biological Treatment of Solid and Hazardous Waste Composting; bioreactors; anaerobic decomposition of solid waste; Principles of biodegradation of toxic waste; inhibition; co-metabolism; oxidative and reductive processes; slurry phase bioreactor; in-situ remediation. Landfill design for solid and hazardous wastes; leachate collection and removal; landfill covers; Thermal Treatment (Incineration) Introduction on greywater management, Faecal sludge management, Bio-degradable waste management. [14 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Integrated solid waste management, G. Tchobanoglous, H. Theisen, S. A Vigil, Mc Graw Hill, 2019 2. John Pichtel Waste Management Practices CRC Press, Taylor and Francis Group 2005. 3. LaGrega, M.D. Buckingham, P.L. and Evans, J.C. 4. Hazardous Waste Management, McGraw Hill International Editions, New York, 1994. Suggested Reference Books: 1. Richard J. Watts, Hazardous Wastes - Sources, Pathways, Receptors John Wiley and Sons, New York, 1997. 2. Elements of Environmental Science and Engineering, P. Meenakshi, PHI (1 December 2012) 3. Environmental Pollution Control Engineering – C.S. Rao

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2			3	3	3			1	2
CO2	3	1	2			3	3				1	2
CO3	3	1	2			3	3				1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHO542	**FUELS & COMBUSTION**	PEL	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: Learn different sources of energy and basic terminology • CO2: Identify characteristic properties of fuels and analyze fuel processing equipment • CO3: Compare performances and select type of fuel processing equipment						
Topics Covered	**Module I:** Introduction: Survey of different sources of energy and their utilization. Fossil fuels: Coal, Petroleum and gaseous fuels. Coal: Origin and formation of coal. Petrographic constituents of coal, Properties and testing. Classification of coal, Coal preparation- washing and blending, Metallurgical and other uses. Carbonisation of coal, coke ovens and recovery of by-products. [15 hrs.] **Module II:** Petroleum: Constitution of petroleum, Origin and Occurrence of crude, Evaluation of crude, Properties, testing and specifications of petroleum products- Octane no.; Reid vapor pressure; Flash point; Fire point; Smoke point; Pour point; Cloud point; Aniline point and Diesel index; Cetane no., Processing of Crude Petroleum. [12 hrs.] **Module III:** Gaseous fuels: Classification. Manufacture of producer and water gas. Combustion and furnace: Combustion characteristics, Combustion appliances--furnaces, waste heat recovery system, burners. [11 hrs.] **Module IV:** Non-conventional energy sources: Solar energy, Wind, Tidal Energy, Wave Energy, Energy from biomass, [4 hrs.]						
Text Books, and/or reference material	Suggested Text Books: 1. Modern Petroleum Refining: B. K. B. Rao 2. Fuels & Combustion: Samir Sarkar Suggested Reference Books: 1. Petroleum Refining Engineering: W. L. Nelson 2. Petroleum Refining Technology & Economics: J.H. Gary & G.E. Handwerk 3. The elements of fuel technology: G. W. Himus						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	3	3	2	3	3	3	2	3
CO2	3	3	3	1	3	3	2	3	3	3	3	3
CO3	3	3	3	1	3	3	2	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHO 543	**INDUSTRIAL WATER TREATMENT**	PEL	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: Learn different sources of energy and basic terminology • CO2: Identify characteristic properties of fuels and analyze fuel processing equipment • CO3: Compare performances and select type of fuel processing equipment						
Topics Covered	**Module I:** Introduction to water resource management issues, access to safe drinking water, river pollution, water quality standards, sources and classification of pollutants.[4hrs.] **Module II:** Chemical Treatment Technology: aeration, chemical coagulation-precipitation, neutralization, chemical oxidation, adsorption, ion-exchange, And advanced oxidation, disinfection of water [6 hrs.] **Module III:** Biological Water Treatment Technology: Biodegradability of water pollutants, selection of technology, microbial growth kinetics, bioreactor configurations, conventional biological treatment, hybrid biological treatment, advances in biological treatment [8 hrs.] **Module IV:** Water treatment by membrane technology: Membrane-based processes, membrane modules, micro, ultra, nano, reverse osmosis, membrane distillation in water treatment. Forward osmosis, FO-NF integrated technology [8 hrs.] **Module V:** Industry-specific treatment of water: Coke oven wastewater treatment, Pharmaceutical wastewater treatment, tannery wastewater treatment, petroleum refinery wastewater treatment, pulp and paper industry wastewater treatment [7 hrs.] **Module VI:** Nanotechnology in water treatment, Hybrid Water Treatment Technologies: Chemical-biological, biological-membrane, membrane-c chemical hybrid treatment technologies in water treatment, sustainable water treatment, ethics, compliance of regulations [7hrs.]						
Text Books, and/or reference material	Suggested Text Books: 1. Industrial Water Treatment Process Technology, P. Pal, Elsevier Science 2. Groundwater Arsenic Remediation: Treatment Technology and Scale Up, P.Pal, Elsevier Science Suggested Reference Books: 1. Wastewater Treatment, Disposal, Reuse, Eddy and Metcalf						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	3	3	2	3	3	3	2	3
CO2	3	3	3	1	3	3	2	3	3	3	3	3
CO3	3	3	3	1	3	3	2	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO541	Fundamentals of Algorithms	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Data Structures		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Will be able to analyse the time complexity of algorithms. • CO2: Able to map real life problems into algorithmic framework. • CO3: Will have concept of different algorithm design paradigm.						
Topics Covered	1. Non-linear data structures. Trees. Binary search trees, AVL tree. (5L) 2. Set Representations. Disjoint Set Union. Priority Queues. (4L) 3. Graph Representations. AND-OR graphs. BFS. DFS. (4L) 4. Algorithm analysis techniques, asymptotic complexity, Big-Oh, Big-omega and Theta notation, Lower bound analysis. (5L) 5. Divide and Conquer. Analysis of Binary Sort, Merge sort, Heap sort, Quicksort, Selection problem, Multiplication of two large n-bit numbers, Strassens' Matrix Multiplication. (7L) 6. Greedy Techniques. Minimal Spanning Trees, Knapsack problem, Huffman's Codes. Job Scheduling. (6L) 7. Dynamic Programming. All Pairs. Shortest Paths, Matrix Chain Multiplication Problem, Traveling Salesperson Problem. (5L) 8. Backtracking. N-Queens problem. Sum of Subsets. (3L) 9. Introduction to NP Hard problems. (3L)						
Text Books, and/or reference material	**Text Books:** 1. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, Introduction to Algorithms, by Prentice Hall India. 2. J. Kleinberg and Eva Tardo, Algorithm Design by Pearson Education (Indian edition). **Reference Books:** 1. Michael T. Goodrich and Roberto Tamassia, Algorithm Design: Foundations, Analysis, and Internet Examples, Second Edition, Wiley, 2006.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	3	2	-	-	-	-	-	-	2
CO2	2	3	3	3	2	-	-	-	-	-	-	2
CO3	2	3	3	3	2	-	-	-	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering						
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours			Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours
CSO542	Database Management System	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))				
Fundamental knowledge in Programming and Data Structures		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**				
Course Outcomes	• CO1: Understand the basic concepts and appreciate the applications of database systems. • CO2: Comprehend the fundamentals of design principles for logical design of relational databases. • CO3: Apply the query writing skill and its subsequent optimization. • CO4: Discuss the basic issues of transaction processing and concurrency control.					
Topics Covered	**Introduction:** Concept & Overview of DBMS, Applications, Data Models, Database Languages, Database Administrator, Database Users, Three Schema architecture of DBMS. (3L) **Entity-Relationship Model:** Basic concepts, Design Issues, Mapping Constraints, Keys, Entity-Relationship Diagram. (5L) **Relational Model:** Structure of relational Databases, Various Relational Algebra operations used to write a query, Views. (5L) **SQL:** Concept of DDL, DML, DCL. Basic Structure, Set operations, Aggregate Functions, Referential views, Nested Subqueries. (5L) **Index Structures:** Necessity of index structures, Types of Single-Level Index (primary, secondary, clustering), Multilevel Indexes. (3L) **Normalization:** Functional Dependency, Anomalies in a Database, The normalization process: Conversion to first normal form, Conversion to second normal form, Conversion to third normal form and BCNF, Fourth Normal form and fifth normal form, Denormalization, Loss-less join decomposition, Dependency preservation. (6L) **Transaction processing:** Introduction of transaction processing, advantages and disadvantages of transaction processing system, online transaction processing system, serializability. (4L) **Concurrency Control:** Serializability by Locks, Lock Modes, Lock based Concurrency Control, Concurrency Control by Timestamps. (4L) **Query Optimization:** Heuristics in Query Optimization, Converting Query Tree to Query Evaluation Plan. (3L) **Distributed Database (DDB):** Introduction of DDB, DDBMS architectures, Data Replication, Data Fragmentation. (4L)					

Text Books, and/or reference material	**Text Books:** 1. "DatabaseSystem Concepts", Abraham Silberschatz, Henry F. Korth and S. Sudarshan, McGraw-Hill. 2. "Distributed Databases Principles & Systems", Stefano Ceri and Giuseppe Pelagatti, McGraw-Hill International Editions. **Reference Books:** 1. "Fundamentals of Database Systems", Ramez Elmasri and Shamkant B. Navathe, Addison-Wesley.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	2	1	1	1	1	1	1	2	2
CO2	3	3	3	3	2	2	2	1	1	2	2	2
CO3	2	3	3	3	3	2	1	1	2	2	2	2
CO4	3	2	2	2	1	1	1	1	1	1	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO543	Computer Organization	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
CSC01 (Introduction to Computing)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Analyze the various parts of a modern computer functional units, bus structure, addressing modes and Computer arithmetic. • CO2: Identify the process involved in executing an instruction and fetching the word from memory. • CO3: Design the hardwired and micro-programmed control units and implementation of interrupts. • CO4: Understand the memory hierarchy and design a memory system.						
Topics Covered	**UNIT-I**: Introduction: Evolution of computers, Basic Structure of Computers: Basic Operational Concepts, GPR based and stack based organisation. Bus Structures, Performance Measurement: Processor Clock, Basic Performance Equation, Clock Rate, Machine Instructions and Programs: Memory Location and Addresses, Memory Operations, Instructions and Instruction Sequencing, Addressing Modes. (10L) **UNIT-II**: Fundamental concepts of the processing Unit: Fetching and Storing words, Register Transfer, Execution of instruction, Arithmetic Operations: Addition and Subtraction of Signed Numbers, Design of Fast Adders, Combinational and Sequential ALU, ALU expansion strategies, Floating Point Numbers (IEEE754), Floating Point Operations. (10L) **UNIT-III**: Computer Organization and Design (Datapath and control path): Instruction codes, computer registers, computer instructions, timing & control, instruction cycle, memory reference instructions, Hard-wired Control, Micro programmed Control: Micro instruction, Microprogram sequencing, Input/output Organization: Accessing I/O Devices, Interrupt, Bus Arbitration schemes. (Brief overview of 8085/8086 microprocessor). (12L) **UNIT-IV**: Memory System: Basic Concepts, Semiconductor RAM Memories, Read Only Memories, Speed, Size, and Cost, Cache Memories – Mapping						

	Functions, Replacement Algorithms, page mode access, interleaved access. Performance Considerations, Virtual Memories, Secondary Storage. (10L)
Text Books, and/or reference material	**Text Books:** 1. David A Patterson, John L Hennessy, "Computer Organization and Design", (The Hardware/Software Interface) Morgan Kaufmann. 2. Carl Hamacher, Zvonko Vranesic, Safwat Zaky: Computer Organization, 5th Edition, Tata McGraw Hill. **Reference Books:** **1. William Stallings, "Computer Organization and Architecture".** 2. Nicholas P Carter, "Computer Architecture & Organisation".

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	1	-	-	-	-	-	-	1
CO2	3	1	2	2	1	-	-	-	-	-	-	-
CO3	3	1	3	3	1	-	-	-	2	-	-	-
CO4	3	2	3	3	2	-	-	-	1	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO544	Operating Systems	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Introduction to Computing (CSC01), Data Structures and Algorithms (CSC303)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		• CO1: Explain the functional architecture of an operating system. • CO2: Design the process control algorithms, solution to deadlocks and multi-threading applications • CO3: Implement application programs using UNIX system calls. • CO4: Design and solve control & data access synchronization problems. • CO5: Explain virtual memory organization and management in OS. • CO6: Implementation of standard FAT & UNIX file system.					
Topics Covered		**Introductory Concepts:** Introduction to Operating System as a whole, memory, CPU (registers and ALU), Evolution of Operating System-types of OS(advantages and drawbacks), Performance measurement metrics. (4L) **Process Data Structures and State transitions:** Process management, Basic Definitions, Process table, PCB (process control block), PTE(process table entry), Process states, Transition diagram, context of process-user level, kernel-level and process Level. (3L) **Process Control:** Process creation, Parent and Child processes, System calls--fork(), exit(), wait(), kill(), Signal handling, Process scheduling strategies-FCFS, SPN, SRT, Round Robin, HRRN, Fair share scheduling. (5L) **Multi-threading:** Threads in OS, thread vs process, Applications of threads, Use of POSIX threads library. (3L) **Process synchronization -** Race condition, Critical section, Process Sync Solution using Algorithmic approach (Lamport bakery Algorithm), Creating shared memory using POSIX library. (2L) **Semaphore**- Binary and Counting semaphore, P() and V() operations, Solving Classical problem using semaphores- Sleeping barber, Producer-					

	consumer, Reader-writer, Dining philosophers's problem, Posix library for semaphores. (6L) **Deadlocks** - Necessary and sufficient conditions for deadlocks, approaches to deal with deadlocks, Deadlock Prevention, Avoidance (Banker's algorithm) and Detection. (3L) **Memory organization & management** - Virtual memory organization, Pure Paging, Pure Segmentation, Combined Paging-Segmentation, Inverted PMT, Page fault handling algorithms, Working set theory. (10L) **File management**- Directory structure, Storage of files on disks, contiguous and non-contiguous file allocation strategies, Internal and external fragmentation, FAT & Inode Structure, Free Space management, Disk scheduling strategies. (4L) **I/O management concepts** (2L)
Text Books, and/or reference material	**Text Books:** 1. "Operating System Concepts", Silberschatz and Galvin. 2. "Operating Systems: Internals and Design Principles" by William Stalling. 3. "Operating Systems: A Concept-Based Approach" by D M Dhamdhere. **Reference Books:** 1. "Operating System: A Design-oriented Approach" by Charles Crowley. 2. "Operating Systems: A Modern Perspective" by Gary J Nutt. 3. "Design of the Unix Operating Systems" by Maurice Bach. 4. "MODERN OPERATING SYSTEMS" by Andrew S Tanenbaum. **Others:** • https://nptel.ac.in/courses/106/106/106106144/# Course "Introduction to Operating Systems" by PROF. CHESTER REBERIO, IIT Madras. • https://nptel.ac.in/courses/106105214/ Course "Operating System Fundamentals" by Prof. Santunu Chattopadhyay, IIT Kharagpur.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	3	-	2	2	1	-	1	2	1
CO2	3	3	1	3	3	1	-	-	-	1	-	-
CO3	-	3	3	-	3	-	-	-	-	1	1	1
CO4	1	3	2	3	3	1	-	-	-	1	3	1
CO5	1	2	2	3	3	1	-	-	-	1	3	1
CO6	-	-	3	-	3	3	2	-	1	2	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO540	Mechatronics	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous (CT), Mid-Term (MT), End Assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	• CO1: **Understand** characteristics of mechatronics system • CO2: **Apply qualitative analysis** techniques in mechatronics system • CO3: **Apply quantitative analysis** techniques in mechatronics system • CO4: **Understand** basic building blocks of general mechatronics system • CO5: **Design** general mechatronics system with functional blocks • CO6: **Investigate complex designs** in mechatronics system and case studies
Topics Covered	Introduction to mechatronics (1L) Sensors and Transducers, Pneumatic and Hydraulic, Mechanical Actuation Systems, Electrical actuation systems (8L) Signal Conditioning circuits (4L) Digital Processing Elements (3L) Data Presentation Systems (2L) System models and Dynamic response (3L) System Transfer functions and frequency response (3L) Closed loop controllers (2L) Artificial Intelligence (2L) Microcontrollers and programming (4L) Interfacing and communication (2L) Case studies (8L)
Text and/or reference Books	**Text Book**: 1. Mechatronics, by W. Bolton, Fourth Edition, Pearson

COURSE ARTICULATION MATRIX

PO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**
CO#1	3	2	1	1	1	1	1	1	1	1	1	1
CO#2	3	2	1	1	1	1	1	1	1	1	1	1
CO#3	2	3	1	1	1	1	1	1	1	1	1	1
CO#4	1	1	3	2	1	1	1	1	1	1	1	1
CO#5	1	1	3	2	1	1	1	1	1	1	1	1
CO#6	1	1	2	3	1	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO541	Probability Theory for Engineering Application	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT), End Assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: Characterize probability models and random variables. CO2: Evaluate moments, correlation, and understand the concept of point estimation, hypothesis testing, inequalities and probabilistic limits. CO3: Recognize, interpret and apply a variety of statistical methods that occur						

	in engineering.
Topics Covered	1. Introduction: Basics of probability theory and statistics for engineers, total probability theorem, Bayes' theorem, Bernoulli's Trials. (3L) 2. Continuous type random variables: CDF, PDF; Types – uniform, exponential, Gaussian, Rayleigh, Weibull etc. Markov inequality, Chebyshev's inequality, Function of random variables, moments and characteristics function. (7L) 3. Discrete type random variables: conditional PMF, Types – Binomial, Geormetric, etc.; mean, variance of discrete random variables. (3L) 4. Two random variables: Joint density and distribution function, independence, two functions of two random variables, and central limit theorem. (3L) 5. Frequency distribution, histogram, random sampling, sampling distributions, t- distribution, chi-square distribution, CLT, point estimation, ML estimation, MAP, method of moments, interval estimation, confidence intervals. (8L) 6. Hypothesis testing, type I and type II errors, p values; t – test, goodness of fit. (5L) 7. Nonparametric test: the sign test, Wilcoxon rank sum test, F distribution, F – test, Chi-square test. (5L) 8. Regression analysis, correlation, analysis of variance (ANOVA), MTBF, reliability. (8L)
Text Books, and/or reference material	**Text Books**: 1. Douglas C. Montgomery, George C. Runger, Applied Statistics and Probability for Engineers, 5th Ed., New Delhi, 2014. 2. Bruce Hajek, *Probability with Engineering Applications, ECE 313 course notes*; Dept. of Electrical and Computer Engineering, University of Illinois, January 2013. 3. J. Ravichandran, *Probability and Statistics for Engineers*, 1st Ed., Wiley, New Delhi, 2014. 4. George R. Cooper, C. D. McGillem, *Probabilistic Methods of Signal and System Analysis*, Oxford University Press, 3rd Ed. , New Delhi, 2007 **Reference Books**: 5. K. S. Trivedi, *Probability and Statistics with Reliability Queuing and Computer Science Applications*, 2nd Ed., Wiley, New Delhi, 2016. 6. Alberto Leon-Garcia, *Probability and Random Processes for Electrical Engineering*, Pearson Education Inc., 2nd Ed., 2007 7. B. S. Grewal, *Higher Engineering Mathematics*, 4th Ed., Khanna Publishers, Delhi, 1998. 8. Erwin Kreyszig, *Advanced Engineering Mathematics*, 9th Ed., Wiley, Delhi, 2013. **Other references**: 9. R. Maity, *Probability methods in Civil Engineering*, NPTEL video lectures. 10. A. Tangirala, *Introduction to statistical hypothesis testing*, NPTEL. 11. A. Kannan, *Statistics of experimentalists*, NPTEL video lectures.

COURSE ARTICULATION MATRIX

PO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	3	2	2	1	1	1	-	-	2	2	1
CO#2	3	2	2	1	1	1	1	-	-	-	1	-
CO#3	3	2	2	3	2	2	2	1	-	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

<table>
<tr><td colspan="8">Department of Electronics and Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO542</td><td>Artificial Intelligence and Soft Computing</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods:
Continuous (CT), mid-term (MT) and End Assessment (EA)</td></tr>
<tr><td colspan="2">Introduction to Computing (CSC01) & Computer Programming Languages like Python, C++, Matlab etc.</td><td colspan="6">CT + MT + EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After the completion of the course the student will be able to learn the following:
•CO1: Basics of optimization and soft computing algorithms
•CO2: Learn different soft computing algorithms
•CO3: Learn artificial neural network and its training
•CO4: Study of radial basis function neural and its training
•CO5: Study of machine learning algorithms and clustering</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I. Introduction to Optimization and soft computing algorithms [L-8]
Introduction to optimization, Constrained and unconstrained optimization, Introduction to Optimization based on soft computing, Genetic algorithms, particle swarm optimization
Module II. Review of different soft computing algorithms part-I [L-7]
Flower pollination algorithm, Teaching learning based optimization
Module III. Review of different soft computing algorithms part-II [L-5]
Crow search algorithm, Quantum Particle swarm optimization
Module IV. Basics of artificial neural network and its training [L-7]
Introduction to artificial neural network, Supervised Learning Neural Networks, Perceptrons, Adaline, Multilayer feed forward neural network, Training of neural network using backpropagation algorithm
Module V. Radial basis function neural networks and K-means clustering [L-5]
Radial Basis Function Neural Networks (RBF), Training of RBF using pseudo inverse technique, Data clustering using K-means
Module VI. Study of machine learning algorithms [L-10]
Extreme learning machine (ELM), Training and testing of ELM, Recurrent Neural Network(RNN) and long short-term memory (LSTM),Training a LSTM based RNN, Deep learning and Convolutional Neural Network(CNN).</td></tr>
<tr><td rowspan="2">Text Books, and/or Reference material</td><td colspan="7">Text Books:
1. S N Sivanandam, S.N.Deepa, “Principles of Soft Computing,” Wiley,3rd edition,2018
2. Samir Roy & Udit Chakraborty, “Introduction to Soft Computing,” Pearson,1st edition,2013
3. Satish Kumar, “ Neural Networks: A Classroom Approach”, McGraw-Hill (India), 2013
4. Shai Shalev-Shwartz and Shai Ben-David, “Understanding Machine Learning: From Theory to Algorithms, “Cambridge University Press”,2014</td></tr>
<tr><td colspan="7">Reference books:
1. S. Rajasekaran and G.A.V.Pai, “Neural Networks, Fuzzy Logic and Genetic Algorithms”, PHI,2003
2. Jang, Sun, Mizutani, “Neuro-Fuzzy and Soft computing”, Pearson,2015
3. Simon Haykin, “Neural networks and learning machines,” Pearson,3rd edition, 2009
4. Charu C.Aggarwal, “Neural Networks and Deep learning,”Springer,2018</td></tr>
</table>

COURSE ARTICULATION MATRIX

PO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	2	2	1	1	2	1	1	1	1	1	1
CO#2	3	3	3	2	2	2	1	1	1	1	1	1
CO#3	3	3	2	2	2	1	2	1	1	1	1	1
CO#4	3	2	2	3	3	2	1	1	1	1	1	1
CO#5	3	2	2	2	2	2	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEO540</td><td>MEASUREMENTS AND INSTRUMENTATION</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">EEC01 (ELECTRICAL TECHNOLOGY)</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Given specifications of different measuring instruments for measurement of particular parameter of some known electrical system, compare and judge to find the most suitable one.
• CO2: Given application of electrical engineering for measurement of particular parameter along with specified range and accuracy, choose most suitable measuring instrument with the understanding of individual working principles, also judge to fit the given application.
• CO3: For some specific parameter to be measured, along with the given range, resolution, accuracy and output format, choose suitable sensor, design associated signal conditioning and analog/digital processing circuit to meet the desired specification.
• CO4: Given parameters to identify the location of fault.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Method of measurement, Measurement system, Classification of instruments, Definition of accuracy, Precision, Resolution, Speed of response, Error in measurement, Classification of errors. (3)
Measurement of Voltage and Current: Principle of operation and torque equation of Moving coil, Moving iron instruments. (5)
Extension of instrument ranges. (2)
Measurement of Power & Energy: Principle of operation of Electrodynamic & Induction type wattmeter, Power measurement by two wattmeter, Construction, theory and application of AC energy meter. (6)
Measurement of resistance: Measurement of medium, low and high resistances, Megger (6)
AC Bridges: Measurement of Inductance, Capacitance, Frequency, mutual inductance (8)
Localization of Cable fault: Methods used for localization of ground and short circuit fault. (4)</td></tr>
</table>

	Sensors & Transducers: Introduction to sensors & Transducers, Strain gauge, LVDT, Temperature transducers, Piezo-electric transducer, pressure transducer, Flow measurement using magnetic flow measurement. (8)
Text Books, and/or reference material	Text Books: 1. K. Sawhney, A course in Electrical & Electronic Measurements & Instrumentation, Dhanpat Rai& sons. 2. E. W. Golding & F. C. Widdis, Electrical Measurement & Measuring Instruments, Wheeler Publishing Reference Books: 1. H. S. Kalsi, Electronics Instrumentation, Mc-Graw Hill Education. 2. A. J. Bouwens, Digital Instrumentation, Tata Mc-Graw hill.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	1	1	2	2	2	2
CO2	3	2	3	2	2	2	1	1	3	2	1	2
CO3	3	2	3	2	2	2	1	1	2	1	2	1
CO4	3	2	2	2	2	2	2	2	2	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO541	FUNDAMENTALS OF CONTROL SYSTEMS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MAC01 (MATHEMATICS-I) MAC02 (MATHEMATICS-II)		CT+MT+EA					
Course Outcomes	• CO1: To get the knowledge of basic objectives of control system design • CO2: To derive input-output relationship of systems based on their mathematical modeling governed by basic laws of physics • CO3: To justify stability of systems based on their transfer functions, time domain and frequency domain specifications • CO4: To develop concepts on root pattern with variable gains and comment on the stability • CO5: To determine the stability of closed-loop system based on open loop frequency response • CO6: To be able to design controllers so as to meet design specifications both in time as well as frequency domain • CO7: To be able to realize the controller both in software simulation through MATLAB coding as well as in real-time environment.						
Topics Covered	**Introduction to control systems:** Historical development, Open and Closed loop systems, Applications, Effects of feedback, Types of feedback control systems, Servomechanism. (4) **Mathematical Models of Physical Systems:** Modeling of electrical networks, Modeling of mechanical system elements, Transfer functions, Block diagram Algebra, Signal flow graph and Mason's Gain formula. (6) **Introduction to State Variable Approach:** Concepts of state, state variables and state model state models for linear Continuous-time systems,						

	state transition matrix. (4) Representation of Control Components: Electrical components, Mechanical components, Electromechanical Components. (2) **Time domain analysis and design specification of linear systems:** Standard signals, Transient response and s-plane root locations of Second and higher order systems, Design specifications, steady state errors and error constants, effects of adding poles and zeros to transfer functions, P, PI, PD and PID controllers. (6) **Concepts of Stability and Algebraic Criterion:** Concept of stability, Characteristic equation & necessary conditions for stability, Routh-Hurwitz stability criteria. (4) **Root Locus Technique:** The concept of root locus, Analytical construction of Root Loci, Root-locus Plots with MATLAB. (4) **Frequency Response Analysis and Stability Studies in Frequency Domain:** Frequency domain specifications, correlation between time and frequency response, Polar plots, Bode plots, Nyquist stability criterion, Relative stability, conditionally stable system, M and N loci on complex and gain phase plane, MATLAB tools and case studies. (8) **Design and Compensation Techniques:** Preliminary considerations of classical Design, Realization of Basic compensators, Frequency domain and s-plane design techniques, Example of control systems. Design with MATLAB.(4)
Text Books, and/or reference material	Suggested Text Books: 1. J. Nagrath and M Gopal, Control system Engineering, New Age Intl. Pub. 2. K. Ogata, Modern Control Engineering, Prentice Hall. 3. B. C. Kuo, Automatic Control system, John Wiley & Sons Suggested Reference Books: 1. Norman S. Nise, Control system Engineering, John Wiley & Sons 2. B. Shahian and M. Hassul, Control System Design using MATLAB, PHI

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	2	2	1	3	1	2	2
CO2	3	3	3	3	2	2	2	1	3	1	1	1
CO3	3	3	3	2	2	1	2	2	3	1	1	1
CO4	2	3	2	2	1	1	2	1	2	1	1	1
CO5	3	3	3	2	2	1	3	1	2	1	1	1
CO6	2	3	3	2	3	2	3	1	3	1	1	1
CO7	2	3	3	3	3	3	3	2	3	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO542	POWER SYSTEM ANALYSIS AND DESIGN	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	• CO1: Given Specification leads to design of network, choice of optimal Voltage, Transmission line and its material, considering the factors like sag, tension and corona. • CO2: Given Specification leads to study of suitable system parameters and incorporating laws of Power systems to choose the most applicable. • CO3: Given Specification emphasizes on the different Tariff structures, by which one can able to judge, compare and select a suitable Tariff plan. • CO4: Given Specification emphasize on the design of equipment's, on the basis of power factor. • CO5: Given specification will give knowledge about the different types of faults and its severity, which can help to design the protection schemes for those faults
Topics Covered	Fundamentals of Power systems: Transmission line (single phase and three phase), per unit systems, Line constants. (1) Load characteristics: Introduction, connected load, variable Load on Power Station, Load Curves, Important terms and factors, Load duration curve-Load curves and selection of generating units, base load and peak load of power station. (6) Mechanical Design of Overhead Lines, Sag and Tension: General consideration, Line supports, type of steel towers, Sag and tension, Sag and tension calculation, Parabolic method, Catenary method, Sag and tension charts. (7) Corona: Phenomenon of corona, disruptive critical voltage, visual critical voltage, corona loss, factors and conditions affecting corona loss. (3) Balanced and unbalanced fault: Introduction, effects of faults, symmetrical fault, symmetrical components, unsymmetrical faults. (5) Load flow studies: Network model formulation, formation of Ybus, load flow problem, Gauss-Siedel method, Newton-Raphson method, Decoupled load flow studies, comparison of load flow methods. Advantages and disadvantages. (7) Power system stability: Steady state stability, transient stability, equal area criteria, swing equation, multi machine stability concept and methods for improving stability. (8) Economic operation of power system: Incremental fuel cost, economic dispatch neglecting transmission losses, transmission loss as a function of plant generation, General loss formula, Optimum load dispatch considering transmission losses. (5)
Text Books, and/or reference material	Text Books: 1. H. Cotton & H. Barber, The Transmission and Distribution of Electrical Energy, Hodder Arnold 2. 2. A. R. Bergen, V. Vittal, Power Systems Analysis, Pearson Edition Reference Books: 1. John J. Grainger & William D. Stevenson, Power system analysis, Tata McGraw Hill Education. 2. D. P. Kothari & I. J. Nagrath, Modern Power System Analysis, Tata McGraw Hill Education

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	2	2	2	1	1	2	2
CO2	3	3	2	2	1	1	1	1	2	1	2	2
CO3	3	2	1	1	1	2	1	2	1	1	1	2
CO4	3	3	2	1	2	1	1	2	1	2	2	1
CO5	3	3	3	2	1	2	1	2	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="7">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEO 541</td><td>Experimental Methods in Engineering</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Nil</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: Acquire an idea about basic concepts of engineering measurements
CO2: To learn the basics of data analysis
CO3: To learn the fundamentals of data acquisition.
CO4: To learn the measurement techniques for electrical signals, pressure, temperature, flow, force, motion, vibration etc.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">• Basic concepts: Calibration, Standards, Dynamic Measurement, System response and Fourier Analysis 4
• Data analysis: Error analysis, Uncertainty analysis, Statistical analysis, Curve fitting, Goodness of fit. 6
• Measurement of electrical signals: Waveform measurements, Analog/digital meters, Amplifiers, Signal Conditioner, Oscilloscope, transducers 5
• Measurements of physical variables: Pressure measurement 4
• Flow measurement 6
• Temperature measurement 4
• Force/ torque/ strain measurement, motion and vibration measurement. 9
• Data acquisition and processing: Signal conditioning, Data transmission, ADC and DAC 4</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="6">Text Books:
1. Experimental Methods for Engineers – J. P. Holman</td></tr>
<tr><td colspan="6">Reference Books:
1. Instrumentation, measurements and experiments in Fluids by E. Rathakrishnan
2. Handbook of experimental fluid mechanics by Foss et al.
3. Measurement systems—application and design, Doebelin, E. O.</td></tr>
</table>

<table>
<tr><td colspan="7">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEO 542</td><td>Introduction to Fluid Mechanics</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Nil</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• CO1: Understanding the basic principles of fluid flow.
• CO2: Relate the fluid-dynamic involved in single phase flow.
• CO3: Plan elementary analysis of most liquid Flow.
• CO4: Analyze the model to a wide variety of complex engineering problems.
• CO5: Plan elementary analysis of fluid flow systems.
• CO6: Conclude the Hydrodynamics flow situations.</td></tr>
</table>

Topics Covered	• **Introduction:** Definition of fluid, Continuum hypothesis, Scope of fluid mechanics, Flow pattern: Streamlines, Streak line and Path line. Differential versus Integral Approach. **(3L)** • **Kinematics of flow:** Lagrangian and Eulerian Approach, Reynolds transport Theorem for integral analysis, Acceleration of Flow, Material derivatives, Angular deformation of a fluid element, Stream-function, Problems. **(4L)** • **Fluid property and governing equation of static and inviscid fluid:** Newtonian Fluid and Non-Newtonian fluids, Surface tension, Euler Equation, Governing equation of statics, Bernoulli's Equation., Problems **(4L)** • **Flow measurement:** Flow measurement by Venturimeter, Orifice meter and Pitot tube, problems. **(3L)** • **Dynamics of viscous flows:** Continuity equation in different coordinates, Navier-Stokes equation and Energy equation. General structure of conservation equations. **(4L)** • **Flow through pipes:** Loss of energy in pipe, loss of energy due to friction (Moody's diagram)), minor losses in pipe, hydraulic and energy gradient line, piping system, flow through branched pipe, power transmission through pipes, problems, problems. **(4L)** • **Boundary layer theory:** Derivation of boundary layer equation, Order-of-magnitude analysis, Flow over flat plate, Separation of boundary layer over a circular shape. Different examples **(7L)** • **Turbulence:** Eddies and vortex shredding, statistical description of turbulent flow, Reynolds stresses, Reynolds averaged Navier stokes equation, Prandlt's mixing length, Wall effect in turbulent flow. **(7L)**
Text Books, and/or reference material	**Text Books:** 1. R. W. Fox,P. J.Pritchard,A. T Mcdonald, Introduction to Fluid Mechanics, John Wiley 2. F. M White, Fluid Mechanics, Tata McGraw Hill Eduction. 3. S K Som, G Biswas,Suman Chakraborty, Introduction to Fluid Mechanics and Fluid machines, Tata McGraw Hill Education.

BASKET - 3

Department of Humanities & Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO740	Indian Writings in English	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	• CO1: Students will develop an understanding of History, Politics, Literature, and the place of English in India with a special emphasis on the pursuit of nuclear weapons in the subcontinent which is the moral equivalent of Civil War.						
Topics Covered	The Course will undertake a detailed study of Amitav Ghosh's *Countdown* with reference to the following topics: 1. History, Politics, Literature, and the Place of English in India (4) 2. Post-Nuclear India (4) 3. Historical Concepts of Indo-Pakistan Relations (4) 4. Thematic Concerns of Amitav Ghosh (4) 5. Ghosh's contribution to Indian Literature (4) 6. Close reading and analysis and discussion of *Countdown* (18) 7. Political struggle in the subcontinent can bring only immeasurable disaster (4)						
Text Books, and/or reference material	Text Book: 1. Countdown—Amitav Ghosh						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	2	2	2	-	-	-	3

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO 741	Development Economics and Sustainable Development	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	1. Develop an understanding about the basic concepts of Economics and Sustainable Development. 2. Know various Indian economic problems and significance of those for growth and development.
Topics Covered	Unit 1: Economic Growth - (3L) Unit 2: Development I - (3L) Unit 3: Development II - (3L) Unit 4: Problems of Capital Formation I - (3L) Unit 5: Problems of Capital Formation II - (3L) Unit 6: Problems of Capital Formation III - (3L) Unit 7: Institutions and Economic Development I - (3L) Unit 8: Institutions and Economic Development II - (3L) Unit 9: Planning Problems I - (3L) Unit 10: Planning Problems II - (3L) Unit 11: Trade and Development I - (3L) Unit 12: Trade and Development II - (3L) Unit 13: Sustainable Development I - (3L) Unit 14: Sustainable Development II - (3L)
Text Books, and/or reference material	1. Ray, D. (2003), *Development Economics*, New Delhi: OUP. 2. Sen, A. (2001), *Development as Freedom*, New York: Oxford University Press. 3. Thirlwall, A.P. (2005), *Growth and Development*, ELBS. 4. Patil, R. B. (Ed) (2014), *Sustainable Development*, New Delhi: Rawat Publications. 5.Peet, R. (2005), Theories of Development, New Delhi: Rawat Publications.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
CO1	2	2	3	3	2	3	3	3	2	2	3	3
CO2	1	3	3	3	2	3	3	3	2	2	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO742	Culture and Communication	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: To be able to analyze the basic concepts of communication across cultures and investigate the notions of cultural production, cultural identity, cultural difference and global cultural change CO2: Understanding the process and implications of communication in the development of different cultural groups, subgroups and communities in the era of globalization						

Topics Covered	❖ Introduction to Cultural Studies (5) ❖ Fundamentals of Communication for the Study of Culture: Theories and Principles (5) ❖ Defining Gender, Class, Ideology and Power (4) ❖ Role of Communication in a Global Village (5) ❖ Multiculturalism and Intercultural Communication (5) ❖ Diaspora and Communication (3) ❖ Impact of Popular Culture, Subculture and Counterculture (5) ❖ Social Media, Networking and Cross-Cultural Experiences (5) ❖ Development Communication and Social Change (5)
Text Books, and/or reference material	1. Gudykunst, W. B., & Mody, Bella (Eds.). (2002). *Handbook of international and intercultural communication*. Los Angeles: Sage Publications. 2. Jandt, Fred E. (2015). *An introduction to intercultural communication: Identities in a global community*. Los Angeles, CA: Sage Publications. *3.* Dasgupta, S., Sinha, D. Chakravarti, S. (2011). *Media, gender and popular culture in India: Tracking change and continuity*. Thousand Oaks, Calif. : Sage Publications *4.* Durham, M. G., & Kellner, D. M. (Eds.). (2009). *Media and cultural studies: KeyWorks*. Massachusetts: Blackwell Publishers. 5. Mukerji, C., & Schudson, M. (Eds.). (1991). *Rethinking popular culture: Contemporary perspectives in cultural studies*. CA: University of California Press.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	2	-	-	3	3	-	3
CO2	-	-	-	-	-	2	-	-	3	3	-	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHO741	**Nuclear Reactor Technology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes		CO1: To understand basic properties of a nucleus and nuclear reaction. CO2: To procure knowledge of the action of nuclear reactor. CO3: To understand neutron physics and diffusion theory. CO4: To learn the utility, protection and control of nuclear reactor.					
Topics Covered		**General Nuclear Properties:** Nuclear mass, Mass defects, Binding energy, Liquid drop model, Semi-empirical mass formula, Energy losses by charged particles and gamma rays. [6] **Nuclear Reaction:** Types of nuclear reaction, Cross-section of a nuclear reaction, Neutron induced reactions, Nuclear fission, Separation energy and fissionability, Fission cross section for slow and fast neutrons, Energy release in fission, Fission fragments and energy distribution, Nuclear fusion and thermo-nuclear reaction. [6]					

	Neutron Physics and Diffusion Theory: Properties of neutron, Neutron sources, Slowing down of neutrons, Neutron scattering, Moderating ratio, Diffusion of thermal neutrons, Diffusion equation, Slowing down without absorption, Slowing down and diffusion, Critical size of reactors slabs, Cubical, Spherical and cylindrical reactors. Variation of neutron cross-section with neutron energy. [10] **Chain Reaction & Fuel Cycle:** Criticality factor, Moderating ratio, Four-factor formula, Reactor kinetics, Reactor poisons, Nuclear fuel cycle, Enrichment of uranium, Back end of fuel cycle. [6] **General Features of a Nuclear Reactor:** Classification of reactors, Basic components. Outlines of BWR, PWR, GCR and FBR with their basic features and characteristics. [6] **Nuclear Reactor Materials:** Fuel fabrication, Moderators, Heavy water production, Control elements, Structural materials. Reactor protection and control. [8]
Text Books, and/or reference material	**TEXT BOOKS:** **1.** Nuclear Reactor Engineering, Glasstone & Sesonske. **2.** Atomic & Nuclear Physics, S. N. Ghoshal. **3.** Nuclear & Particle Physics, S. L. Kakani, S. Kakani. **REFERENCE BOOKS:** 1. Introduction to Nuclear Reactor Theory, J. R. Lamarsh. 2. Nuclear Physics, I. Kaplan. 3. Nuclear Energy, David Bodansky. 4. Nuclear Physics, D. C. Tayal.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
PHO 741	CO1	3	1	1	2	1	1	2	1		1		2
	CO2	3	3	1	2		1	2	2		1		3
	CO3	3	3	2	2		2	2	1		1		2
	CO4	3	3	3	3	1	3	3	3		1	1	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO740	GENETIC ENGINEERING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	**CO1:** Students will acquire basic understanding of molecules of life and their basic chemistry. **CO2:** Students will acquire knowledge of how genetic material stores programs of life and how that information is retrieved. **CO3:** Students will acquire knowledge of basic tools of genetic engineering and their applications. **CO4:** Students will be able to apply the acquired knowledge in understanding and solving biotechnology issues surrounding us.
Topics Covered	1. Structures of macromolecules such as Carbohydrates, Proteins, Enzymes, Lipids and Nucleic Acids. [10] 2. Basics of cell biology, prokaryotes vs. eukaryotes, sub-cellular structures, their organization and functions. [10] 3. Central Dogma of molecular biology, DNA Replication, Transcription, Reverse Transcription, Translation. [10] 4. Basic tools of nucleic acid manipulation. Methods of genetic engineering; Genetic engineering of microbes, plants and animals. [12]
Text Books, and/or reference material	Suggested Text Books: 1. Essential Cell Biology, 4th Edition, Albertset. al. 2. Biotechnology.2nd Edition, 2015. David Clark and Nanette Pazdernik.Academic Cell. 3. Cecie Starr, Christine A. Evers, Lisa Starr. Biology: Today and tomorrow with physiology. Suggested Reference Books: 1. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter, Molecular Biology of the Cell, Garland Science. 2. Molecular Biology of the Gene by James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick.

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											1
CO2	2											1
CO3	2						2	2				1
CO4		1	1			2						1

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO740	**Mechanics of Composite**	**Program Elective (PEL)**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Knowledge of Solid Mechanics, Structural		Continuous (CT) and end assessment (EA). CT+EA					

Analysis & Design	
Course Outcomes (COs) :	· CO1: Development of skills of finding out mechanical properties of composite materials as well as predicting structural behaviour of composites under different loads. · CO2: Knowledge of basics of analysis and design of structural components, made of variety of composite materials. · CO3: Knowledge of using numerical tools for modeling and analysis of simple structural components
Topics Covered (Hrs)	- Introduction, Types of composite materials, Lamina and Laminate, Matrix and Fibre, Fibre-reinforced Composites, Comparison of strengths between bulk material and fibres. **(6)** - Co-ordinate systems, Effect of orientation of fibres on the strength and stiffness of Composites. **(6)** - Brief outline of manufacturing processes. **(4)** - Micromechanics and Macro mechanics, Constitutive relations, Stresses and Strains, Failure criteria of composites. **(8)** - Analysis of Composites: beams and plates **(12)** - Finite Element Method in analysis of Composite Structures **(6)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Mechanics of Composite Materials by Robert M. Jones: Taylor and Francis (2015) 2. Mechanics of Composite Structures by Autar K. Kaw, Taylor and Francis (2006) ***Reference Books:*** 3. Mechanics Of Composite Materials and Structures by Madhujit Mukhopadhyay, University Press (2004)

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	-	3	2	-	-	-	-	-	-	-	-	-
CO3	-	2	-	-	3	-	-	-	-	-	-	-

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO741	**Optimization in Engineering Design**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods					
No pre-requisites		Continuous (CT) and end assessment (EA). CT+EA					

Course Outcomes	· CO1: Develop optimization models for any engineering system. · CO2: Solve optimization problems. · CO3: To learn about modern optimization methods
Topics Covered	**Introduction:** Model, Steps in modeling: Formulation, Deduction, Interpretation, Ten Principles of Modeling, Design Process, Differences Between Engineering Analysis and Design, Comparison Between Conventional Design and Optimal Design. **(4)** **Introduction to optimization model formulation in engineering design:** Objective & Constraint function, Development of objective & constraint functions, Example formulations, Classification of optimization models**. (4)** **Solution Techniques:** Linear programming: Linear Programming Problem, Graphical Solution, Linear Programming in Standard Form, Handling Inequality Constraints, Handling Variables Unrestricted in Sign, Basic Definitions in LP, Canonical reduction, Principles of the Simplex Method, Simplex Method in TABLEAU Form, Computational Problems, Big M Simplex Method, Two-Phase Simplex Method. Revised Simplex Method, Integer Programming, Fixed Charge Problem Formulation. **(8)** **Nonlinear programming – 1:** Single variable unconstrained minimization, Basic Definitions, Optimality Criteria, Introduction to line search techniques**. (4)** **Nonlinear programming – 2:** Multivariable unconstrained optimization, Optimality Criteria, Introduction to various Algorithms for Minimization. **(4)** **Nonlinear programming – 3:** Multivariable constrained optimization, Equality Type Constraints, Lagrange Multiplier, Inequality type Constraints, Optimality Criteria Transformation Methods, Penalty Function Algorithm, Introduction to Linearization Methods, Introduction to Reduced Gradient Method, Introduction quadratic programming, Introduction to projected augmented Lagrangian Method. **(10)** **Introduction to Advanced topics:** Dynamic & Geometric programming, Chance constrained & Multiple objective optimization, Soft computing techniques - Genetic Algorithm, Simulated Annealing Technique, Fuzzy logic, Artificial Neural Networks. **(8)**
Text Books, and/or reference material	***Text Books:*** 1. Engineering Hydrology by R. S. Varshney, Nem Chand & Bros. Roorkee (U.P.) 1986. 2. Operations Research – Principles and Practice by A. Ravindran, D. J. Philips and J. J. Solberg, 2nd Ed., John Weley & Sons, New York, 1987. 3. Engineering Optimization – Theory and Practice by S. S. Rao, 3rd Edition, New Age Int. (P) Ltd. Publishers, New Delhi, 2001. ***Reference Books:*** 4. Nonlinear Programming – Theory and Algorithms by M. S. Bazaraa & C. M. Shetty, John Wiley & Sons, New York, 1990. 5. Introduction to Optimum Design by J. S. Arora, McGraw Hill Int. Editions, McGraw Hill Book Co. Singapore, 1989.

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	3	3	-	-	-	-	-	-	-	-	-
CO2	-	3	3	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO742	**Theory of Elasticity and Plasticity**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisites:	Course Assessment methods
Engineering and Solid Mechanics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes	· CO1: To develop basic understanding of the behaviour of materials. · CO2: To define the stress and strain behaviour of structural elements. · CO3: To apply theory of elasticity in bending and torsion problems. · CO4: To apply theory of plasticity in failures of different materials and structures.
Topics Covered	**Stress & Strain**: Stress equilibrium equations, rectangular, cylindrical and spherical co-ordinates, Generalized Hooke's Law, Stress and strain compatibility equations. Plane stress and plane strain problems, Airy's stress function, Principal Stresses and strains, stress & strain invariants, numerical problems. **(15)** **Torsion**: Shafts of circular and non-circular prismatic sections, Saint Venant theory, warping function, stress function. **(7)** **Theories of Failure**: Basic concepts and Yield Criteria, Different Theories of Failure, Yield Locus and Yield Surfaces. Equations of Plasticity. **(8)** **Plasticity**: hydrostatic stresses, deviatoric stresses, invariants of deviatoric stresses, yield criteria, von Misses, Tresca yield criteria, theories of plastic flow, plane stress, plane strain problems in plasticity, thick cylinders, thick spheres. **(12)**
Text Books, and/or reference material	***Text Books:*** 1. Theory of Elasticity and Plasticity by S. Timoshenko, MC Graw Hill. 2. Theory of Elasticity and Plasticity by Sadhu Singh, Khanna Publishers. ***Reference Books:*** 3. Advanced Strength of materials by Papov, MC Graw Hill Book Company. 4. Plasticity for structural Engineers by W. F. Chen and D. J. Han, Springer-Verlag, New York.

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO 5	PO6	PO7	PO8	PO 9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-
CO3	3	3	2	2	-	-	-	-	-	-	-	-
CO4	3	3	2	2	-	-	-	-	-	-	-	-

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHO741	**NON-LINEAR DYNAMICS**	PEL	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: To understand the physics of dynamic complexity of a nonlinear process • CO2: To identify strange attractors and to estimate their degree of complexity • CO3: To learn relevant mathematical methods for solving nonlinear problems						
Topics Covered	**Module I:** Theories of ODEs: First-order ordinary differential equations, basic ideas. Definitions of stability and elements of linear algebra. Stability of homogeneous linear systems, fundamental stability theorem for nonlinear systems. Uniqueness Conditions for Linear and Nonlinear Systems [10 hrs.] **Module II:** Periodic solutions and Bifurcations: Phase portraits; Hopf bifurcations; period doubling; Poncare maps; RuelleTakens scenario; Floquet matrices and stability. Maps; Reduction of flows to maps; Reconstruction of phase space from one-dimensional signals. [11 hrs.] **Module III:** Quantitative analysis of strange attractors: Liouville's theorem and conservation of areas in phase space; Sensitivity to initial conditions; Stretching and folding;.Lyaponov exponents; Fractal dimension; power spectrum, Lyapunov exponents and Lyapunov functions [11 hrs.] **Module IV:** Case studies: Logistic equation, Lotka-Volterra predator-prey mechanism, Oscillating Chemical Reactions: Brusselator and Oregonator, Lorenz and Rössler attractors, adiabatic and nonadiabatic CSTRs, fermenters, boiling flows, etc. [11 hrs.]						
Text Books, and/or reference material	Suggested Text Books: 1. Pushpavanam, S., Mathematical Methods in Chemical Engineering, PHI Learning 2. Strogatz, S. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry and Engineering, Westview Press; 2nd edition (2014) Suggested Reference Books: 1. Robert Hilborn, Chaos and nonlinear dynamics : An introduction for scientists and engineers						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			1	1							
CO2	3	2	1	1	1						1	
CO3	3	2	1	1	1						1	

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO741	Software Engineering	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Identify and describe software life cycle model and their roles in building software project. • CO2: Recognize the feasibility of functional and non-functional requirements applying decision tree/table minimization techniques/methodologies for a particular problem. • CO3: Apply modularity in project resulting design of flexible software code with reusability. • CO4: Effectively use existing testing strategy to test the software and make sure the reliability of the software and analysis of quality of the software. • CO5: Apply the project management tools, estimation techniques to handle the project.						
Topics Covered	**UNIT I:** Overview of System Analysis & Design, Software Development Life Cycle, Waterfall Model , Spiral Model, Feasibility Analysis, Technical Feasibility, Cost- Benefit Analysis, COCOMO model. [10L] **UNIT II:** System Requirement Specification – DFD, Data Dictionary, ER diagram, Process Organization & Interactions. [10L] **UNIT III:** System Design – Problem Partitioning, Top-Down And Bottom-Up design; Decision tree, decision table and structured English; Functional vs. Object- Oriented approach. [10L] **UNIT IV**: Coding & Documentation - Structured Programming, OO Programming, Information Hiding, Reuse, System Documentation. Testing – Levels of Testing, Organizing for software testing; Software Testing Strategy; Unit Testing: Unit Test Considerations; Integration Testing, OO testing, Reliability Assessment, Validation & Verification Metrics, Monitoring & Control. [8L] **UNIT V:** Software Project Management– Project Scheduling, Staffing, Software Configuration Management, Quality Assurance, Project Monitoring. [4L] CASE TOOLS : Concepts, use and application.						
Text Books, and/or reference material	**Text Books:** 1. Roger S. Pressman, Software Engineering: A practitioner's approach, McGraw Hill. 2. Ian Sommerville, Software Engineering, Pearson. **Reference Books:** 1. Rajib Mall, Fundamentals of Software Engineering, Prentice Hall India. 2. Pankaj Jalote, An integrated approach to Software Engineering, Springer/Narosa.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	2	1	1	1	2	1	2	2
CO2	3	3	1	2	2	1	1	1	2	1	2	1
CO3	2	3	2	2	2	2	2	-	2	2	2	2
CO4	1	1	3	3	3	1	1	1	2	2	-	-
CO5	1	2	3	3	3	1	1	1	2	2	2	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 742	**Multimedia Technologies**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Knowledge of data structures databases and compression techniques		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: In depth understanding of media characteristics and resource requirement. • CO2: Understanding text, graphics. Audio, video media types. • CO3: Knowledge of issues on dealing simultaneously with multiple data formats, temporal and spatial constraints, synchronization aspects, SAS factors. • CO4: Understanding of data compression techniques of different media. • CO5: Understanding of multimedia database storage and retrieval.						
Topics Covered	Overview of multimedia system: Text, audio, video and graphics. (3L) Video and Animation: Capturing Graphics and Images Computer Assisted Graphics and Image Processing; Reconstructing Images; Graphics and Image Output Options. Basics; Television Systems; Digitalization of Video Signals; Digital Television; Basic Concepts; Virtual Reality, Video signal representation, Computer Video Format, Computer- Based animation, Animation Language, Methods of controlling Animation, Display of Animation, Transmission of Animation. (10L) Information representation, media synchronisation, SAS factors, relative and absolute temporal specifications, networking delays, Skew, Jitter. (6L) Data Compression: Storage Space requirement, Coding Requirements Source, Entropy Coding, Lossy Sequential DCT- based Mode, Expanded Lossy DCT-based Mode, JPEG and MPEG. (8L) Multimedia file systems: Difference of MM file systems with traditional systems, disk management, disk scheduling, common scheduling algorithms. (5L) Multimedia databases, multimedia query types, index structures to handle multimedia databases, data storage and retrieval. (10L)						
Text Books, and/or reference material	**Text Books:** · Multimedia: Computing, Communications and Applications, Ralf Steinmetz and Klara Nahrstedt, Pearson Education Asia. · Multimedia Communications, Applications, Networks, Protocols and Standards, Fred Halsall, Pearson Education Asia. · Multimedia Systems, John F. Koegel Buford, Pearson Education Asia. **Reference Books:** · Subrahmanian and Jajodia, Multimedia Database Systems, Springer.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="8">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSO 743</td><td>Computer Networks</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3">Fundamental knowledge in Data Structures</td><td colspan="5">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand the basic taxonomy and terminology of the computer networking and enumerate the layers of OSI model and TCP/IP model.
• CO2: Comprehend the fundamentals of Physical layer, and will apply them in real time applications.
• CO3: Identify data link layer concepts, design issues, and protocols.
• CO4: Classify the routing protocols and analyze how to assign the IP addresses for the given network.
• CO5: Acquire knowledge of Application layer and Presentation layer paradigms and protocols.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Data communications: components, data representation, direction of data flow; physical structure (type of connection, topology), categories of network (LAN, MAN, WAN); Protocols and standards; Reference models: OSI reference model, TCP/IP reference model. [3L]
Physical Layer: Overview of data (analog & digital), signal (analog & digital), transmission (analog & digital) & transmission media (guided & unguided); Circuit switching: time division & space division switch, TDM bus. [5L]
Data link Layer: Types of errors, error detection & correction methods; framing, Flow control Protocols: Stop & wait ARQ, Go-Back- N ARQ, Selective repeat ARQ, Medium Access sublayer: Token Ring; Reservation, Polling, Multiple access protocols: Pure ALOHA, Slotted ALOHA, CSMA, CSMA/CD, CSMA/CA. [10L]
Network layer: Internetworking & devices, Addressing: IP addressing, subnetting; Routing : techniques, static vs. dynamic routing , Unicast Routing Protocols, Congestion Control and Quality of service (QoS). [12L]
Transport layer: Process to Process delivery; Socket address,UDP; TCP. [5L]
Application Layer: Introduction to DNS, SMTP, SNMP, FTP, HTTP & WWW. [5L]
Network Security : Encryption/and decryption algorithms, authentication, access control, Security standards - IS/ISO 27000, 18000 introduction. [2L]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. B. A. Forouzan – “Data Communications and Networking (3rd Ed.) “ – TMH.
2. A. S. Tanenbaum – “Computer Networks (4th Ed.)” – Pearson Education/PHI.
3. W. Stallings – “Data and Computer Communications (5th Ed.)” – PHI/ Pearson Education.
Reference Books:
1. Comer – “Internetworking with TCP/IP, vol. 1, 2, 3(4th Ed.)” – Pearson Education/PHI.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="7">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSO744</td><td>Computational Biology and its Applications</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and End assessment (EA))</td></tr>
<tr><td colspan="2">Introduction to Computing, Linear Algebra, Fundamentals of Probability and Statistics</td><td colspan="5"></td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• CO1: To develop the problem solving skill using the concept of algorithms
• CO2: To understand different computational algorithms including few clustering and classification techniques and genetic algorithm.
• CO3: To aware the basic principles and concept of Biology and identify the potential application areas.
• CO4: To correlate the computational algorithms and the applicable biological domain.
• CO5: To develop new computer modelling for different types of biological data</td></tr>
<tr><td>Topics Covered</td><td colspan="6">1) Algorithms in Computing: Algorithms, Pseudocode, Time & Space Complexity, Dynamic Programming. (4)
2) Pattern Matching and Optimisation: Hashing, Pattern Finding using Clustering, Genetic Algorithms, Evolutionary Computation Techniques, Case Study on GA based feature selection on microarray gene expression (8)
3) Hidden Markov Model: Markov process and Models, HMM applications (6)
4) Support Vector Machine: Introduction, Margin, Hyperplane, Classification. Bayes Theorem, Bayes Classifier. Case Study on Disease Classification(6)
5. Artificial Neural Network: Perceptron, Hidden Layers, Activation Functions, Feed Forward Neural Network and Back Propagation, Case Study on Biological</td></tr>
</table>

	Image Classification (6) 6) Basics of Biology: Central Dogma of Molecular Biology, Molecular Visualisation Softwares, Protein Sequence and Structure Analysis, Protein Structure Modelling, Protein-protein Docking, Genomics. (12)
Text Books, and/or reference material	**References:** 1. An Introduction to Bioinformatics Algorithms, Neil C. Jones, Pavel Pevzner, MIT Press. 2. Bioinformatics: the Machine Learning Approach, Pierre Baldi, Soren Brunak MIT Press. 3. Genetic Algorithms in Search, Optimization and Machine Learning, David E. Goldberg.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	3	2	1	1	1	-	-	1	1
CO2	2	3	3	3	2	1	1	1	-	-	1	2
CO3	2	3	3	3	2	1	1	1	-	-	1	2
CO4	2	3	3	3	2	1	1	1	-	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO740	Biomedical Instrumentation	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and End Assessment (EA))					
Basic Electronics (ECC01), Engineering Mechanics (XEC01)		Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination					
Course Outcomes	After the completion of the course the student will be able to • **CO 1**: Understand concept of Biomedical Instrumentation • **CO 2**: Understand basic building blocks of Biomedical Instruments • **CO 3**: Apply quantitative analysis techniques to Biomedical Instruments • **CO 4**: Learn design techniques of Biomedical Instruments • **CO 5**: Investigate application specific Biomedical Instruments						
Topics Covered	**Module I: Introduction to Biomedical Measurements and Instrumentation [L-1]** **Module II: Static and dynamic characteristics of Biomedical Instruments [L-7]** Static characteristics of elements, Dynamic characteristics of elements, Quasi-static characteristics of elements, Static characteristics of systems, Dynamic characteristics of systems, linearity, non-linearity, Sensitivity, Resolution, Repeatability, Reproducibility, Response time, Settling time, Gain, bandwidth						

	Module III: Error and Noise in Biomedical Measurements [L-4] Sources of noise in measurement systems, mathematical modelling of noise, environmental effects, Effects of Interfering and Modifying inputs, Error analysis, Systematic error, Random error. Statistical methods for noise and error analysis and Modelling. **Module IV: Reliability analysis of Biomedical Instruments [L-4]** Concept of Reliability, Reliability of measurement systems, Reliability enhancement strategies **Module V: Operation of Physiological organs, Bioelectric Potentials and Electrodes [L-7]** Operation of Physiological organs, Operation of Nerves system, Operation of heart, Operation of lungs, Operation of Muscular system, Sources of bioelectric potentials, Bioelectric electrodes **Module VI: Building blocks of Biomedical Instruments [L-9]** Bioelectric sensors, Sensors, Signal conditioning circuits, Bridge circuits, Amplifiers, Filters, Oscillators, ADC, Signal Processing Units, Microcontrollers, Data Presentation elements **Module VII: Application Specific Biomedical Instruments [L-10]** Clinical thermometer, Sphygmomanometer, Digital Statoscope, ECG signal measuring instrument, EEG signal measuring instrument, Medical Imaging techniques, Assistive Respiratory system
Text Books, and/or reference material	**Text Books:** 1. John G. Webster, *Medical Instrumentation Application and Design*, 4ed, Wiley, 2015 2. J. Bentley, *Principles of measurement systems*. Pearson Education India; 3rd edition, 2002 3. R.S. Khandpur, *Handbook of Biomedical Instrumentation*, 3rd Edition, McGraw Hill Education;, 2014 **Reference Materials:** 1. Research Articles

COURSE ARTICULATION MATRIX

PO / CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	-	-	-	-	2	-	-	-	-	-	-
CO#2	2	3	-	-	-	-	-	-	-	-	-	-
CO#3	1	3	-	-	-	-	-	-	-	-	-	-
CO#4	2	1	2	-	-	2	-	-	-	-	-	-
CO#5	1	1	1	3	-	2	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Electronics and Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO741</td><td>Embedded Systems</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and End Assessment (EA))</td></tr>
<tr><td colspan="3">Basic Electronics (ECC01)</td><td colspan="5">Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After the completion of the course the student will be able to
• CO1: Understand use of Microprocessor in Microcontrollers and Microcomputer
• CO2: Interface I/O devices with Microprocessor in Microcontrollers and Microcomputer
• CO3: Design software controlled hardware systems
• CO4: Investigate application specific embedded systems</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I: Intel 8051 Microcontroller [L-4]
Architecture of Intel 8051 Microcontroller using functional blocks, Crystal oscillators, Digital I/O Pins, Digital I/O ports, 8051 Microcontroller programmer, limitations of Intel 8051 Microcontroller.
Module II: ATmega Microcontrollers and Arduino [L-4]
Architecture of ATmega Microcontrollers using functional blocks, Hardware components of Arduino boards, ADC, Analog input pins, Digital I/O pins, PWM signals, PWM pins, Serial communication pins, Arduino shields, Limitations of ATmega Microcontrollers and Arduino.
Module III: Raspberry Pi Micro-Computer [L-4]
ARM processor, Hardware components of Raspberry Pi Micro-computer, GPIO pins in Raspberry Pi board, PWM signals, Raspberry Pi OS, In-built data communication devices, Limitations of Raspberry Pi Micro-Computer.
Module IV: I/O devices for Micro controllers and Microcomputers [L-5]
Sensors, Resistive sensors, Capacitive sensors, Inductive sensors, Actuators, Motors, Signal conditioning circuits, Amplifiers, Filters, Display elements, Data storage devices, Compatibility of several transducers with Intel 8051 Microcontroller, ATmega Microcontrollers and Arduino, Raspberry Pi Micro-Computer
Module V: Embedded System Programming using Keil [L-7]
Keil editor and compiler, Keil Programming for Intel 8051 Microcontroller, Program uploading to 8051 Microcontroller, I/O programming, Interfacing Analog and Digital sensors and actuators with Intel 8051 Microcontroller, Interrupt programming in 8051, Keypad and Display element interfacing with 8051.
Module VI: Embedded System Programming using Arduino language [L-7]
Arduino editor and compiler, Arduino Programming, Program uploading to Arduino board, I/O programming, Interfacing Analog and Digital sensors and actuators with Arduino, Serial communication and Data transmission in Arduino, Interrupt programming in Arduino, Keypad and Display element interfacing with Arduino.
Module VII: Embedded System Programming using Python [L-7]
Raspberry Pi OS, Python programming, Interfacing Analog and Digital sensors and actuators with Raspberry Pi, I/O programming in Raspberry Pi, Serial</td></tr>
</table>

	communication and Data transmission in Raspberry Pi, Interrupt programming, Keypad and Display element interfacing with Raspberry Pi. **Module VIII: Case studies [L-4]** Application specific embedded system design using 8051 Microcontroller, Arduino, Raspberry Pi, Password lock device using Embedded system, Smart home using embedded system, Motor controller using Embedded system
Text Books, and/or reference material	**Text Books:** 1. T. Givargis, F. Vahid , *Embedded System Design: A Unified Hardware / Software Introduction*, Wiley; Student edition, 2006 2. E. A. Lee, S. A. Seshia*, Introduction to Embedded Systems - a Cyber Physical Systems Approach*, PHI Learning Pvt Ltd, MIT Press; Second edition, 2019 3. M. A. Mazidi, *The 8051 Microcontroller and Embedded Systems: Using Assembly and C*, Pearson Education India; 2nd edition, 2007 **Reference books:** 1. J. Bentley, *Principles of measurement systems*. Pearson Education India; 3rd edition, 2002 2. T. W. Schultz, *C and the 8051, Vol.I: Hardware, Modular Programming & Multitasking*, Prentice Hall; 2nd edition, 1997 3. S. Monk, *Programming Arduino: Getting Started with Sketches*, Second Edition, McGraw-Hill, 2nd edition, 2016 4. J. Yiu, *The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors*, Newnes; 3rd edition, 2013 5. S. Monk, *Raspberry Pi Cookbook: Software and Hardware Problems and Solutions,* Shroff/O'Reilly; Second edition, 2016 6. D. Molloy, *Exploring Raspberry Pi: Interfacing to the Real World with Embedded Linux*, Wiley; 1st edition, 2016 7. Research Articles

COURSE ARTICULATION MATRIX

PO / CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	-	-	-	-	2	-	-	-	-	-	-
CO#2	3	1	-	-	-	-	-	-	-	-	-	-
CO#3	1	3	-	1	-	-	-	-	-	-	-	-
CO#4	1	1	-	3	-	2	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO742	Mobile Communication	PEL	3	0	0	3	3
Prerequisites		Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA)):					
NIL		Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination					

Course Outcomes	**CO1:** Apply Cellular concepts to evaluate the signal reception performance in a cellular network and traffic analysis to design cellular network with given quality of service constraints. **CO2:** Determine the type and appropriate model of wireless fading channel based on the system parameters and the property of the wireless medium. **CO3:** Analyze and design receiver and transmitter diversity techniques. Evaluate the data rate performance. **CO4:** Application of Fundamental Digital Communication Concepts in Fading Channel. Understanding suitable Modulation Schemes for Wireless Channel **CO5:** Describe and differentiate five generations of wireless standard for cellular networks. Understand wireless communication systems with key 3G (e.g., CDMA); 4G (OFDM) and 5G technologies
Topics Covered/ Syllabus	**Module I. (L - 5)** Introduction to Wireless Personal Communication, Mobile radio systems. **Module II. (L - 10)** Cellular systems concepts, principles, system design fundamentals, spectrum efficiency, frequency management, channel assignment, handoff, power control, Call blocking, Cell splitting and Directional antenna etc. **Module III. (L - 8)** Characterization of wireless radio channel, propagation path models. Fading and Shadowing. **Module IV. (L -12)** Receiver Techniques for fading Channel. Detection of Signal in Fading Channel, Receive Diversity, Transmit Diversity, Equalization, Fading mitigation. Modulation schemes for wireless Communication (MSK, GMSK), OFDM, Multiple access techniques: Spread spectrum techniques, Cellular CDMA, NOMA **Module V. (L - 7)** Wireless Networks and Standards: GSM, CDMA Cellular standard, 3G, 4G
Text Books, and/or Reference material	**Text Books:** [1] Andrea Goldsmith, "*Wireless Communication*", Cambridge University Press [2] Aditya K Jagannathan, "*Principles of Modern Wireless Communication Systems Theory and Practice"*, McGraw-Hill India. [3] David TSE and Pramod Viswanathan, "*Fundamentals of Wireless Communication*", Cambridge University Press **Reference Books:** [1] Theodore Rappaport, "*Wireless Communications: Principles and Practice*", Pearson, 2nd Edition [2] Andreas. F. Molisch, "*Wireless Communication*", John Wiley and Sons [3] Mark and Zhuang, "*Wireless Communication and Networking*", PHI

COURSE ARTICULATION MATRIX

PO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	3	3	1	1	-	-	-	-	-	-	-
CO#2	3	3	3	1	1	-	-	-	-	-	-	-
CO#3	3	3	3	1	1	-	-	-	-	-	-	-
CO#4	3	3	3	2	1	-	-	-	-	-	-	-
CO#5	3	3	3	2	2	-	-	-	-	1	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Electronics and Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 43</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO743</td><td>Internet of Things</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods:
Continuous (CT), Mid-Term (MT), End Assessment (EA)</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Explain the term IoT and understand the main components of IoT systems.
CO2: Recognize, interpret and apply a variety of enabling technologies, connectivity technologies and communication protocols that occur in IoT systems.
CO3: Design and analysis of a complete working IoT system involving prototyping, programming and data analytics</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Introduction to IoT: Introduction and definition of IoT;
-Basics of networking: Network types; Network topologies; OSI model; Adressing TCP/IP;
-Predecessors of IoT: WSN; M2M; Cyber Physical Systems (5L)
2. IoT enabling technologies: (8L)
- Cloud computing; Big data analytics; Embedded systems;
-IoT levels: level 1 to level 6
-Introduction to sensors; actuators; microcontrollers, and their interfacing: Sensors-characteristics, types; Sensor interfacing-interfacing gas sensors with nodeMCU/ Arduino, interfacing pH sensor, interfacing pulse sensor.
-Actuators: types, functions
-Microcontrollers and overview
3. IoT communication technologies:
-Constrained nodes and networks: types; lossy and low power networks
-Protocols for messaging and transport: Messaging protocols- MQTT; CoAp; XMPP; DDS
-Protocols for addressing and identification: IPV4; IPV6; Uniform Resource Identifier (URI); 6LoWPAN; Discovery protocols like universal plug and play; multicast DNS. (6L)
4. IoT connectivity technologies: IEEE 802.15.4; Zigbee; RFID; NFC; Sigfox; LoRa; NB-IoT; WiFi; Bluetooth (2L)
5. Cloud for IoT: challenges; selection of cloud service provider; introduction to Fog computing- working principle; edge and Fog computing; security aspects. (2L)
6. Data analytics: Data analysis; Machine learning: supervised and unsupervised; Types of ML models: classification; regression; clustering; Model building process; modeling algorithm; model performance; Big data platform. (5L)
7. IoT case studies and future trends: Agricultural IoT; Vehicular IoT; Healthcare IoT; Evolution of new IoT paradigms- IoBT; IoV; IoNT; IoD; IoSpace; NFV; SDN; 5G as IoT enabler. (6L)
8. IoT hands on:-Home automation: smart lighting;Air pollution monitoring;Health care: elderly fall detection; Prevention of drowsiness of drivers by IoT based smart drivers assistance systems. (9L)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Shriram K Vasudevan; Abhishek S Nagarajan; RMD Sundaram, Internet of Things, 2nd Edition, Wiley, New Delhi, 2020.
2. S. Mishra, A. Mukherjee, A. Roy, Introduction to IoT, 1st Ed., Cambridge</td></tr>
</table>

University, UK, 2021.

Reference Books:

3. A. Bahga, V. Madisetti, *Internet of Things: A Hands-on approach,* 1st Ed., Universities Press (India) Pvt. Ltd., Hyderabad, 2014.
4. K. N. Raja Rao (editor), *Internet of Things: Concepts and Applications*, 1st ed., Wiley India, 2021.

COURSE ARTICULATION MATRIX

PO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	3	2	1	1	1	1	1	-	2	-	2
CO#2	3	2	2	2	2	1	1	-	-	1	1	2
CO#3	3	2	3	3	3	2	2	1	-	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO740	CONCEPT OF ELECTRICAL MACHINES & DRIVES	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO 1: Get an introductory draft of electrical drive system and discuss different drive systems stability based on fundamental torque equations. • CO2: Explore the motoring principle and design of different parameters of DC and AC motors. • CO3: Calculate different parameters of starters and breakers for DC and AC drive system and know about different starting and braking techniques. • CO4: Understand multi-quadrant operation of DC and AC drive systems and the speed torque characteristics. • CO5: Recognize different speed control techniques of DC and AC drives and compute different speed control system parameters.						
Topics Covered	Concept of electrical drives; Classification, group, individual, multi-motor electric drives; Classification of control schemes and components of electric drives, closed loop control of industrial drives. (6) Speed-Torque characteristics of dc drives; Basic parameter, types of loads, quadrant diagram. Speed-Torque characteristics of dc shunt and series motor. Types of starters and braking (dynamic, regenerative braking) of dc drive. (8) Speed control of dc motor: Basic parameters, method of speed control of dc shunt and series motor. Speed control of dc series motor in a crane using dynamic braking. Introduction to soft control of dc drive. (8) Induction Motor Drives: Three phase I.M., analysis and performance. Operation with unbalanced source voltages and single phasing, analysis						

	of I.M. fed from non-sinusoidal voltage supply. Starting, Braking. Speed control methods of IM, v/f-controlled induction motors, controlled current and controlled slip operation and its application. (12) Stepper, universal, servo and switch reluctance motor drives, solar and battery powered drives, Energy conservation in Electrical Drives. (5) Industrial application of electrical drives: Electric traction, paper mill, textile mill, and coal mines. (3)
Text Books, and/or reference material	Text Books: 1. G. K. Dubey, Fundamentals of Electrical Drives, Narosha Publishing House, 2001. Reference Books: 1. N. K. De and P. K. Sen, Electric Drives, PHI, 2001.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	3	2	1	1	1	1
CO2	3	3	3	3	3	3	2	2	1	1	1	1
CO3	3	3	3	3	2	2	2	1	1	1	1	1
CO4	3	3	3	2	3	2	2	1	1	1	1	1
CO5	3	3	3	2	2	2	2	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO741	BIOMEDICAL INSTRUMENTATION!	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO 1: Familiarization with biomedical equipment's and transducers • CO2: Introduction to biomedical signal conditioners • CO3: Acquiring knowledge about development of bio potentials and their measurements. • CO4: Introduction patient health care monitoring • CO5: Introduction to computerized imaging techniques						
Topics Covered	Introduction to biomedical Instrumentation, biomedical electronics, Components of Analog and digital circuits. (8) Various types of signal conditioners, signal conditioning processes. (8) Generation of Nernst Potential, Establishment of diffusion potential, Goldman Equation, Measurement of membrane potential, resting potential, action potential. (6) Use of electrodes for measurement of bio potentials, polarization in electrodes, principle of operation of Ag/AgCl electrode, Equivalent circuit of electrode. (6) Measurement of ECG, Einthoven triangle method, unipolar and bipolar limb leads, ECG amplifiers, Problems encountered in ECG recording. (6) Introduction to medical imaging, Radiography, Computerized tomography, X Ray, -CT, MRI. (8)						

Text Books, and/or reference material	Text Books: 1. John Enderle. Joseph Brinzino, Introduction to Biomedical Engineering, Elsevier, 2012. 2. John G Webster, Medical Instrumentation, Application & Design, John Wiley & Sons, 2009 Reference Books: 1. L. Cromwell, Fred J. Weibell, Erich A. Pfeiffer, , Biomedical Instrumentation & Measurements, PHI, 2014 2. Arthur C Guyton, John E Hall, Textbook of Medical Physiology, Elsevier, 2006:

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	1	1	3	1	1	2
CO2	3	3	3	3	3	3	1	1	3	1	1	2
CO3	3	3	3	3	3	3	1	1	3	1	1	2
CO4	3	3	3	3	3	3	1	1	3	1	1	2
CO5	3	3	3	3	3	3	1	1	3	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO742	RENEWABLE ENERGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEC01 (ELECTRICAL TECHNOLOGY)		CT+MT+EA					
Course Outcomes	• CO1: To understand the basics of Energy System and overall energy resources • CO2: To design the solar and wind power plant • CO3: To understand the tidal, geothermal energy, biomass and other resources and principles • CO4: To understand the energy conservation opportunities and energy saving						
Topics Covered	Introduction: Energy system as electrical system, Energy chain, National and International Energy scenario, various non-conventional energy resources-importance, classification relative merits and demerits, Carbon emission, carbon credit, Paris environmental meet for awareness of emission. (9) Solar photovoltaic: Introduction, solar radiation & its relationship with photovoltaic effect. Photovoltaic concentration, photovoltaic systems-standalone, Solar Constants, Definition of solar thermal: Thermal characteristics of solar radiation, solar collectors: -materials, types, focusing. Solar thermal power plant: layout and arrangement, solar cooling, recent developments. (8) Wind power and its sources, site selection criterion, wind characteristics, momentum theory, Classification of wind machines. Wind mills-different design & their control, wind generators- different types, wind farms & grid. Wind						

	generation in India. Wind Power and maximum power equation. Wind penetration & its effects, economic issues, recent developments, international scenario. (6) Principles of tidal power generation, components of power plant, Single and two basin systems, Estimation of energy, Maximum and minimum power ranges. Ocean and geothermal Energy, geothermal power plant. OTEC Principle, Open cycle and closed cycle. (4) Bio fuel, Conversion of biomass, Biofuel classification, Biomass production for Energy farming, direct combustion for heat-pyrolysis-thermochemical process, Anaerobic digestion- Digester sizing- waste and residues, vegetable oils and biodiesels, Applications of Biogas, Social and environmental aspects. (5) Fuel Cell: Basic construction & principle of operation of fuel cell, Fuel cell power plants & its integration with wind and solar photovoltaic systems. Geothermal Energy, Dry Steam power plant, Single and Double Flash power plant and integration in electrical system/Grid. (5) Energy conservation opportunities, Type of energy audit, energy audit report. Saving of energy with energy economics. (5)
Text Books, and/or reference material	Text Books: 1. G.D. Rai, Non-conventional energy resources, Khanna Publishers, New Delhi, 2003. 2. N. G. Clavert, Wind Power Principle, their application on small scale, Calvert Technical Press. 3. Fuel Cell Handbook, Parsons Inc. 4. Earnest and T. Wizelius, Wind Power Plants and Projects development, PHI

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**2**	**2**	**1**		**1**	**1**	**1**			**1**	**1**
CO2	**3**	**3**	**2**	**1**	**1**	**1**	**1**				**1**	**1**
CO3	**2**	**3**	**3**	**2**	**1**	**1**	**1**	**1**	**1**		**1**	**1**
CO4	**2**	**3**	**3**	**2**		**1**	**1**	**1**	**1**		**2**	**1**

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering						
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours			Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO743	FLIGHT CONTROL SYSTEMS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CONTROL SYSTEMS (EEC431) FUNDAMENTALS OF CONTROL SYSTEMS (EEO541)		CT+MT+EA					
Course Outcomes	• **CO1:** To develop the concept of the aerodynamics, 6 degrees of freedom motion of aircraft and understanding the role of control surface. • **CO2:** To understand the longitudinal and lateral dynamics of aircrafts and						

	to identify different modes along with the scope of their improvements by designing control law. • **CO3:** To develop the concept of Static and Dynamic Stability of Aircrafts. • **CO4:** To develop insight on margin criterion, the closed loop response specifications and their relationship with the stability and flying qualities of the aircrafts. • **CO5:** To design control law based on Classical Control Theory for Longitudinal and Lateral/directional dynamics to meet the desired margin and flying qualities criteria • **CO6:** To design control law based on Classical Control Theory for Longitudinal and Lateral/directional dynamics to meet the desired margin and flying qualities criteria
Topics Covered	**Motions of Aircraft:** Primary Definitions, 6 DOF Motion, Aerodynamic Angles, Forces and Torques, Aircraft Position and Orientation, Stability-Frame and Body-Frame, Euler's Equations (3) **Linearization of Equations of Motion:** Small Disturbance Theory and Linearization of Equations of Motion, Stability and Control Derivatives (2) **Longitudinal Dynamics:** Aircraft Longitudinal Dynamics, Longitudinal Motion Approximations, Short period mode, Phugoid mode, Influence of Stability Derivatives, Transfer Functions, Flying Qualities (5) **Lateral Dynamics:** Aircraft Lateral Dynamics, Lateral-Directional Equations, Dutch Roll, Roll and Spiral Modes, Approximate Models, Transfer Functions, Flying Qualities (5) **Stability and Control:** Static Stability Basics, Longitudinal static stability, Lateral/directional static stability, Dynamic Stability (3) **Classical Design Techniques for Flight Control:** Review of Control System Analysis/Synthesis Techniques, Closed loop performance specifications, Longitudinal Stability Augmentation System and Control Augmentation System Designs, Lateral Stability Augmentation System and Control Augmentation System Designs, Design for Aileron to Rudder interconnect gain, Concept of Autopilot design, Design of 2 Loop, 3 Loop Roll Autopilot (12) **Advanced Design Techniques for Flight Control:** Design of longitudinal and lateral Stability Augmentation System using Pole Placement, Linear Quadratic Regulator with Output feedback, Linear Quadratic Regulator with full state feedback, Designing Performance Index, Tracking a command (12)
Text Books, and/or reference material	Suggested Text Books: 1. Stevens and Lewis, Aircraft Control and Simulations, Wiley & Sons, 3rd Edn 2. Dynamics of Flight Stability and Control by Etkin and Reid, John Wiley & Sons, 3rd Edn Suggested Reference Books: 1. Flight Stability and Automatic Control by Nelson, WCB/McGraw-Hill, 2nd Edn 2. Introduction to Flight by Anderson, McGraw-Hill, 2nd Edn 3. Guided Weapon Control Systems by Garnell and East, 1st Edn Pergamon Press, 1980

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	1	2	1	2	1	3	1	1	1
CO2	2	2	3	1	2	1	2	1	2	1	1	1
CO3	3	3	3	2	2	1	2	1	3	1	1	1
CO4	3	3	2	2	1	1	2	1	3	1	1	1
CO5	3	3	3	2	2	1	3	1	2	1	1	1
CO6	2	3	3	2	3	2	3	1	3	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>MEO 741</td><td>Non-conventional Energy Systems</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NA</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Identify and explain the use of non-conventional energy systems.
CO2: Develop an understanding that solutions to energy-related problems are complex involving sociological, economic, political and technological considerations, decisions and development.
CO3: Gain insight into the issues surrounding non-conventional energy sources development and use.
CO4: Become knowledgeable about applications of non-conventional energy systems as they apply to commercial, residential and industrial markets.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Traditional energy systems, Sources, Features and characteristics, applications 2
Component of solar energy systems, Collector types and performances, Radiation and meteorological data processing, Long term conversion factors, System conversion and system design procedures, Solar power generation, Solar heating and cooling, Solar passive systems: Solar still, Pond, Greenhouse, Dryer, Trombe wall, Overhangs and Wing walls. 13
Wind energy conversion systems, Estimate of wind energy potential, Aerodynamic and mechanical aspects of wind machine design. 4
Principles and applications of wave energy, Shoreline systems, Near shore systems, Off shore systems 3
Tidal energy, Biomass energy, Operating principle, Wood gassifier, Pyrolysis, Applications, 4
Geothermal energy and OTEC. 4
Fuel cell: Types and technology status. 3
Hydel Power Plant: Introduction to hydro-electric power generation, Types of Hydel turbines, Layout and selection of turbines and installation, Geographic limitations, Turbine performance, Comparative analysis between thermal and hydel plants. 9</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Suggested Text Books:
1) Solar Energy Fundamentals and Applications-- Garg and Prakash
2) Solar Energy-- S. P. Sukhatme
Suggested reference books:
1) Fundamentals of Renewable Energy Systems-- D. Mukherjee and S. Chakrabarti
2) Non-conventional Energy Sources-- D. S. Chauhan and S. K. Srivastava</td></tr>
</table>

<table>
<tr><td colspan="7">Department of Metallurgical and Materials Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMO 541</td><td>Basic Manufacturing Processes</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
</table>

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Engineering Physics (PH-01)	CT+MT+EA

Course Outcomes	CO1: To understand the basic fundamental of structure and properties of metal CO2: To learn fundamentals of different manufacturing process. CO3: To learn science and technological aspects of the different manufacturing techniques
Topics Covered	Introduction: Importance of manufacturing process. Economic & technological consideration in manufacturing. Classification of manufacturing processes. Materials & Manufacturing processes for common items. [4 hours] Crystallography and Equilibrium Phase Diagram: Concept of unit cell space lattice, Bravais lattices, common crystal structure, Defects and dislocation in solids. Uniary and Binary diagram, phase rules, Types of equilibrium diagrams, Solid solution type and combination type. Iron-carbon equilibrium phase diagram. [6 hours] Mechanical Properties: Materials Structure and properties of engineering materials, stress-strain diagrams for engineering materials. Stress vs Strain, toughness, Hardness, Fracture, Fatigue and Creep. Ductile & brittle materials. Heat treatment of steels Annealing, Normalising and hardening. [5 hours] Metal Forming Processes: Forming: Plastic deformation and yield criteria; fundamentals of hot and cold working processes; Load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; Work required for forging operation, Different forging operation, different forging tools. Condition for rolling force and power in rolling. Rolling mills & rolled section. Hot and cold working Rolling, forging, wire & tube drawing, deep drawing extrusion [8 hours] Manufacturing Processes: Metal casting: patterns and moulds making, gating and risering, melting, casting practices in sand casting, permanent mould casting, investment casting and shell moulding, casting defects and repair. [5 hours] Joining: Physics of welding, Process of different welding, common welding processes of shielded metal arc welding, gas metal arc welding, gas tungsten arc welding and submerged arc welding; welding metallurgy, problems associated with welding of steels and aluminium alloys, defects in welded joints. [5 hours] Heat treatment: hardening, annealing, tempering, normalizing, surface hardening, case hardening. [2 hours] Powder Metallurgy: Powder Metallurgy Manufacturing Process. Principles of powder metallurgy. The need, Process, advantage and applications. [3 hours]
Text Books, and/or reference material	Suggested Text Books: 1. Rajender Singh: Introduction to Basic Manufacturing Processes & Workshop Technology, New Age International (P) Limited, Publishers, 2006. 2. Metals Handbook, Casting, vol. 15, 10th Edition, ASM International, Materials Park, Ohio, USA, 1998. Suggested Reference Books: 1. O. P. Khanna: Foundry technology, 17th Edition, Dhanpat Rai Publications, 2011. 2. George. E. Dieter: Mechanical Metallurgy, McGraw-Hill Co. Company.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3								1	1	3
CO2	3	3				1				1	3	3
CO3	3	3				1					3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XEO741	Human Resource Management	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
nil		CT+MT+EA					
Course Outcomes	• CO1: Understanding the different aspects of Human resource in an organization • CO2: Understanding the theory of motivation • CO3: Understanding the correlation of work –rewards- stress.						
Topics Covered	Studying of Characters of individuals in terms of Behavioural Pattern. [4] Framework of human resource development: influences on employee behaviour, learning and HRD, [5] Recruitment Methods and its policy. [1] Applications of human resource development: employee socialization and orientation, skills and technical training, coaching and performance management, mentoring, employee counselling and wellness services. [4] Motivation and Study of Performance appraisal methods. [3] Wage Theory And its application. [2] TQM and empowerment, stress and time management. [4] Trade unions and its role in HRM. [2] HRD, Organizational Learning, and learning organizations [4] HRM in the next century. [1]						
Text Books, and/or reference material	Suggested Text Books: 1) David A. DeCenzo and Stephen P. Robbins, Human Resource Management, Prentice hall of India. 2) Werner and DeSimone (2006). Human Resource Development. Thomson Press, Network. Suggested Reference Books: 1) Ghosh A.K., Human Resource Management, Manas Publications, 2007. 2. Dessler G. Fundamentals of Human Resource Management Pearson Education; First edition, 2010.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	1	1	1	1	1	1	1	1
CO3	3	3	3	3	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

BASKET - 4

DEPARTMENT OF MANAGEMENT STUDIES							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MSO-841	MARKETING RESEARCH AND ANALYTICS	PEL	3	0	0	3	3
Pre-requisites- NIL		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1. Students will be aware of technique of customer segmentation and new product designing CO2. Students will be informed about understanding customer perception on competitive brands CO3. Students will be educated on technique of comparative analysis on various marketing matrix						
Topics Covered	**UNIT I:** Conceptualization and process for conducting research on marketing problems **(5)** **UNIT II:** Application of univariate and multivariate techniques in solving marketing problem. Application of independent sample, before –after T, chi- square statistics to solve marketing problem; Guidelines for application of statistical software.(9) **UNIT III:** Experimental design and its application. Guidelines for application of statistical software.(4) **UNIT IV:** Application of cluster analysis for solving market – segmentation problem. Making of similarity index from categorical data .Distance and correlation based approach for building similarity index. Software based application.(9) **UNIT V:** Application of conjoint analysis in designing consumer preference. Discussion of case studies in relation to design new product /service.(7) **UNIT VI:** Application of other Multivariate techniques for solving relevant marketing problems(10)						
Text Books, and/or reference material	Text Books: 1. Applied Multivariate Statistical Analysis, Richard A. Johnson, Dean W. Wichern, Person Prentice Hall **2.** Multivariate Data Analysis, Joseph F. Hair, William C. Black, Barry J. Babin, Rolph E. Aderson, Person Prentice Hall. 3. Marketing Research: An Applied orientation, Naresh K. Malhotra, Person Prentice Hall 4. Business Research Methods, Prahlad Mishra, Oxford University Press India						

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHO841	**Quantum Physics**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	CO1: To be proficient in the fundamental mathematical languages used, such as matrix algebra, in quantum information theory)2: To understand and implement basic quantum algorithms (Shor, Deutsch-Jozsa etc) CO3: To understand limitations to quantum computation introduced by quantum decoherence CO4: To be knowledgeable about advanced topics such as teleportation, Bell's inequalities and EPR paradox.
Topics Covered	**Quantum Mechanics Introduction** [9] History of quanta, base states and superposition, structural randomness, measurement: how long is a qubit?, Heisenberg's Uncertainty Principle, waveform collapse in the macroscopic limit **Matrix Algebra** [8] Basis vectors and orthogonality, inner product and Hilbert spaces, matrices and tensors, unitary operators and projectors, Dirac notation **Fundamentals of Quantumness** [7] Abramsky-Coecke semantics, no-cloning theorem, quantum entanglement ('spooky action at a distance'), Bell states and Bell inequalities **Quantum Circuits** [6] Pauli, Hadamard, phase, CNOT, Toffoli gates, quantum teleportation, universality of two-qubit gates, reversible computing **Quantum Algorithms** [6] Deutsch-Josza algorithm, Simon's problem, quantum Fourier transform, Shor's period-finding algorithm, quantum key distribution (BB84, E91) **Quantum Error Correction** [3] Error correction codes **Quantum Computers** [3] Physical qubits, noise and decoherence
Text Books, and/or reference material	**TEXT BOOKS:** 1. Phillip Kaye, Raymond Laflamme, and Michele Mosca (2007). An Introduction to Quantum Computing. Oxford University Press. 2. Michael A. Nielsen and Isaac L. Chuang (2000). Quantum Computation and Quantum Information. Cambridge University Press. 3. Mermin, N. David (2007). Quantum Computer Science: An Introduction. Cambridge University Press. **REFERENCE BOOKS:** 1. Yanofsky, Noson S. and Mirco A. Mannucci (2008). Quantum Computing for Computer Scientists. Cambridge University Press. 2. McMahon, David (2008). Quantum Computing Explained. John Wiley & Sons, Inc. 3. Quantum Computing for Everyone

Mapping of CO (Course outcome) and PO (Programme Outcome)

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	1	1	1	1	1	1
CO2	3	3	3	3	3	1	1	1	1	1	1	1
CO3	3	3	3	2	2	1	1	1	1	1	1	1
CO4	3	3	2	2	2	2	1	1	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTO840</td><td>Industrial Biotechnology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Life science</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1- To understand the methods of cell 's bio processing under various conditions, strain improvement methods for better results
CO-2 Demonstrate the experimental techniques associated with aseptic processes, media preparation and related upstream processes
CO-3 .Design and develop medium for cell cultivation for fermentation process Apply the knowledge of sterilization techniques
CO-4 Understand needs of various parts of fermenter and their operation and Design bioreactor based on thumb rules for fermentation operation
CO-5 Apply the knowledge of Purification Separation and kinetics theory of Enzyme production for industrial fermentation</td></tr>
<tr><td>Topics Covered</td><td colspan="7">UNIT 1 CELL CULTIVATION ,GROWTH KINETICS -- 10 Hrs
Media development for Cell growth and culture for microbes , plant, animal -derived cells and its application. Microbial growth kinetics, logistic growth model, growth of filamentous organism Strain improvement of industrial micro organism. Measurement of cell mass. Cell immobilization. Numericals..
UNIT 2-MEDIA PREPARATIONand STERILIZATION 10 Hrs
Sterilization: basic concepts in sterilization in situ and ex-situ sterilization, Sterilization of medium, air, filters, fermenter. Types of media, Strain preservation , inoculum preparation, Development of inocula for industrial fermentation/ seed fermenter
UNIT 3- BIOREACTOR DESIGN AND ITS OPERATION- 12 Hrs
Purpose and importance of bioreactor, Parts of fermenter and types ;Oxygen requirement, Oxygen transfer in fermenter, , KLa measurement, Measurement of dissolved oxygen concentrations, Estimating Oxygen Solubility Operational modes of bioreactor: batch, semi-batch/fed batch,</td></tr>
</table>

	continuous. Major components of bioreactor and its purpose, classification of Bioreactor – SLF, SSF, animal and plant cell culture. Classification of bioreactors for environmental control and management. Fixed bed bioreactor, airlift reactor, hollow fibre reactor, seed reactor. **UNIT 4 INDUSTRIAL ENZYMES ,PURIFICATION and A PPLICATIONS** -10Hour Enzyme engineered for new reactions-novel catalyst for organic synthesis. Case studies: thermozymes cold adopted enzymes. Ribozymes, therapeutic enzymes of industrial importance (amylase, glucose isomerase, cellulose, lipase, protease, xylanase, invertase, peroxidases). Separation of insolubles: filtration, centrifugation. Extraction and purification of solubles: Ultra filtration, high performance tangential flow filtration, Recovery and purification of intracellular products: cell disruption, chromatographic techniques. Analytical assays of purity level of enzymes.
Text Books, and/or reference material	Suggested Text Books: 1. Pauline M. Doran, "Bioprocess Engineering Principles", Academic Press, 2 nd Ed., 2012. 2. El-Mansi (Ed.), "Fermentation Microbiology and Biotechnology", CRC Press, 3rd Ed., 2011. Suggested Reference Books: 1. Ashok Pandey et al., "Enzyme Technology", Springer Publisher, 2006. 2. Nielsen et al., "Bioreaction Engineering Principles", Plenum Publishers, 2nd Ed., 2002. 3. Mohammed A. Desai (Ed.), "Downstream Processing of Proteins: Methods and Protocols", Humana Press, 2000. 4. Satinder Ahuja, "Handbook of Bioseparations", Vol 2, Academic Press, 1st Ed., 2000.

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	1	1				-		-	
CO2	2	3	1	3	2	2	-		-		-	
CO3	1		1	2	2	2	-				-	
CO4	1	2	3	3	-	1	1					
CO5	1	2	3	3	1	2	1					

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>CEO840</td><td>Finite Element Analysis and Applications</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisite(s)</td><td colspan="5">Course Assessment methods</td></tr>
<tr><td colspan="3">Mechanics, Mathematics, Engineering problems in various fields</td><td colspan="5">Continuous (CT) and end assessment (EA). CT+EA</td></tr>
<tr><td>Course Outcomes (COs) :</td><td colspan="7">· CO1: Knowledge of importance of FEA over classical methods and use it for modelling and analysis of real life engineering systems.
· CO2: Learning to simulate physical systems related to various engineering fields through FE modelling & interpret analysis data for prediction of system response.
· CO3: Skill to use computational tools for solving engineering problems.
· CO4: Foundation for using advanced FEA software packages for modelling and analysis of problems related to relevant field of studies in both industry and research.</td></tr>
<tr><td>Topics Covered (Hrs)</td><td colspan="7">Introduction: Recapitulation of Matrix Manipulation Techniques, Solution of Simultaneous Linear Equations, Inverse of Matrix, Eigen Values and Eigen Vectors, Computer Implementation. (5)
Engineering Problems: Different numerical methods, History of Finite Element Method (FEM), Steps in FEM, Areas of Application, Verification problems, implementation of Engineering Problems in FEA. (10)
Spring Element: General, Implementation in FEA, Applications, Problems. (5)
Bar Elements: Definition, Property Matrix using Direct and Energy Approach, Engineering Implementation in FEA, Problems and Validation. (6)
Application of FEA: General Conduction Problems, Mechanical systems, Electrical systems etc. Validation, convergence study and error analysis in solution of real life engineering problems. (10)
Computer Programs/ SOFTWARES in FEA. (6)</td></tr>
<tr><td>Text Books, and/or reference material(s)</td><td colspan="7">Text Books:
1. Finite element analysis: theory and programming by C S Krishnamurthy (2001). Publisher: Tata McGraw Hill Education
2. Finite Element Analysis Theory and Application with ANSYS by Moaveni. Publisher: Pearson (2008)
3. Fundamentals of Finite Element Analysis by David V. Hutton. Publisher: Tata Mcgraw Hill Education Private Limited (2005)
Reference Books:
4. Finite Element Procedures by Klaus-Jurgen Bathe. Publisher: Prentice-Hall (2009)</td></tr>
</table>

Mapping of Course Outcomes COs → POs

	PO1	PO 2	PO3	PO4	PO 5	PO6	PO7	PO 8	PO9	PO10	PO11	PO1 2
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	-	3	-	2	-	-	-	-	-	-	-	-
CO3	-	-	-	-	3	-	-	-	-	-	-	-
CO4	-	2	-	3	-	-	-	-	-	-	-	-

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO841	**Disaster Management and Mitigation**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
None	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs):	· CO1: Understanding Disaster · CO2: Ability to manage disaster · CO3: Use of Modern tools to manage disaster
Topics Covered (Hrs)	**Understanding Disasters:** Understanding the Concepts & definitions of Disaster, Hazard, Vulnerability, Risk, Capacity–Disaster, Development & management **(5)** **Types, Trends, Causes, Consequences and Control of Disasters:** Geological Disasters (earthquakes, landslides, tsunami, mining); Hydro-Meteorological Disasters (floods, cyclones, lightning, thunder-storms, hail storms, avalanches, droughts, cold and heat waves) Biological Disasters (epidemics, pest attacks, forest fire); Technological Disasters (chemical, industrial, radiological, nuclear) and Manmade Disasters (building collapse, rural and urban fire, road and rail accidents, nuclear, radiological, chemicals and biological disasters) Global Disaster Trends – Emerging Risks of Disasters – Climate Change and Urban Disasters **(10)** **Disaster Management Cycle and Framework:** Disaster Management Cycle – Paradigm Shift in Disaster Management Pre-Disaster – Risk Assessment and Analysis, Risk Mapping, zonation and Microzonation, Prevention and Mitigation of Disasters, Early Warning System; Preparedness, Capacity Development; Awareness During Disaster – Evacuation – Disaster Communication – Search and Rescue – Emergency Operation Centre – Incident Command System – Relief and Rehabilitation – Post-disaster – Damage and Needs Assessment, Restoration of Critical Infrastructure – Early Recovery – Reconstruction and Redevelopment **(10)** **Disaster Management in India:** Disaster Profile of India – Mega Disasters of India and Lessons Learnt Disaster Management Act 2005 – Institutional and Financial Mechanism National Policy on Disaster Management, National Guidelines and Plans on Disaster Management; Role of Government (local, state and national), Non-Government and Inter Governmental Agencies **(5)**

	Applications of Science and Technology for Disaster Management: Geo-informatics in Disaster Management (RS, GIS, GPS and RS) Disaster Communication System **(5)**
Text Books, and/or reference material (s)	***Text Books:*** 1. Disaster Management by W. Nick. Carter, 1991: Asian Development Bank, Manila 2. Introduction to International Disaster Management by D. P. Coppola, 2007, Elsevier Science (B/H), London. 3. Manual on natural disaster management in India by M C Gupta, NIDM, New Delhi ***Reference Books:*** 4. An overview on natural & man-made disasters and their reduction by R K Bhandani, CSIR, New Delhi 5. http://www.nidmindia.nic.in/

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	-	-	3	-	2	-	-	-	-
CO2	1	-	-	-	-	3	-	2	-	-	3	-
CO3	1	-	-	-	3	-	-	-	-	-	-	-

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO842	**Experimental methods in Engineering**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Basic Engineering, statistics & probability	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs):	· CO1: Development of skills for predicting engineering system behaviour · CO2: Knowledge of basics of data analysis for further applications. · CO3: Developing the requisite skill that helps in the advanced courses related to experimental study
Topics Covered (Hrs)	**Types of measurements and errors**: Internal & external estimates of errors, Relative frequency distribution, Histogram, True value, Precision of measurement, Best estimate of true value & precision, Methods of calculating best estimate of true value & standard deviation **(7)** **Combination of measurements**: Accuracy of mean, Significant digits. Method of least squares & its application for calculation of best estimate of true value, curve fitting, **(8)** **General linear regression**: Comparison & combination of measurements. Extensions of least square method. Theory of errors, Binomial & Gaussian distribution, Confidence limits, Significance test, principle of maximum likelihood & goodness of fit, Chi-square test. **(9)**

	Displacement measurement: Dial Gauge, Microcator, Optical Method, Pneumatic Transducer, Strain Gauges, Variable Inductance & Capacitance Transducer, Piezo-Electric, Electro-Kinetic, Photo-Electric, Ionization, Vibrating Wire & Vacuum Tube Transducer. **Force & Torque:** Elastic Type, Fluid Load Cell, Dynamometers. **Temperature:** Bi-Materials, Pressure & Resistance Thermometers, Thermocouples & Pyrometers. **Pressure:** McLeod Gauge, Pirani Gauge, Ionization Gauge, Manometers, Bourdon Tube, Resistance Gauges. **Fluid Velocity:** Pitot tube & Hot Wire Anemometer, LDA. Flow Measurement in Confined Passages & Open Channels. Miscellaneous measurements **(10)** **Dynamic Response** of a Measuring Instrument, Response to Transient & Periodic Signals, First & Second-order systems as well as their Dynamic Response Characteristics. (**8)**
Text Books, and/or reference material (s)	***Text Books:*** 1. Instrumentation, Measurement and Analysis by B C Nakra and K K Chaudhary, Tata McGraw Hill, 1985. 2. Principles of Measurement, Precision, Error and Truth by N C Barford, Addison Wesley, 1967. ***Reference Books:*** 3. Physical Measurement and Analysis by N N Cook and E Rabinowicz, Addison Wesley, 1963 4. Experimental Methods for Engineers by J P Holman and W J Gajda, McGraw Hill Co., 1978

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	2	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	-	-	1	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHO841	**BIO-ENGINEERING AND INDUSTRIAL APPLICATION**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MAC01, CYC01		CT+MT+EA					
Course Outcomes	• CO1: Understand the kinetics of different bioprocess for the design of bioreactor. • CO2: Analyze the performance of bioreactors. • CO3: Apply the knowledge of bioprocess for industrial production.						
Topics Covered	**Module I:** [15 hrs.] Introduction of Bioprocesses and their important in process industry; Free enzyme kinetics; Inhibition in enzymatic reactions. Bioreactors for enzymatic reactions.						

	Module II: [15 hrs.] Cell growth kinetics; Growth models, Inhibition in cell growth kinetics, Reactors for cell growth system. Combination of bioreactors for cell growth. **Module III:** [10 hrs.] Downstream processing in bioprocesses; Intra and extracellular product extraction and separation. Industrial application of bioprocesses. **Module IV:** [10 hrs.] Application of enzymatic reactions in industrial production. Production of HFCS. Application of cell growth reactions in industrial production. Biofuel production, waste water treatment.
Text Books, and/or reference material	Suggested Text Books: 1. J. E. Bailey, D. F. Ollis, Biochemical Engineering Fundamentals, Second Edition, Mc. Graw Hill Inc., Singapore, 1986. 2. H. W. Blanch, D. S. Clark, Biochemical Engineering, Special Indian Edition, Marcel Dekker Inc. New York, 2007. 3. M. L. Shuler, F. Kargi, Bioprocess Engineering - Basic Concepts, Second Edition, Prentice Hall of India Private Ltd., New Delhi, 2002. Suggested Reference Books: 1. P. M. Doran, Bioprocess Engineering Principles, Academic Press, California, 2009. 2. J. Nielsen, J. Villadsen, G. Liden, Bioreaction Engineering, Second Edition, Springer, 2007. 3. D. G. Rao, Introduction to Biochemical Engineering, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2008.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	3	1	1	2	2	2	3	1
CO2	3	2	3	2	3	1	1	2	2	2	3	1
CO3	3	2	3	2	3	1	1	2	2	2	3	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHO842	**ENERGY INTEGRATION AND ECONOMICS IN PROCESS INDUSTRY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Heat Transfer		CT+MT+EA					
Course Outcomes	• CO1: To identify and understand the method of data extraction for energy integration in the process industry • CO2: To analyse the process heat data to minimize energy cost. • CO3: To create the low cost heat integrated process.						
Topics Covered	**Module I:** [8 hrs.] Introduction to process Integration (PI) and Pinch Technology. **Concept** of ΔT_{min}, Data Extraction, Composite curve, Grand Composite Curve, Targeting, Graphical representations. Rules of data extraction. Problem Table Algorithm.						

	Module II: [8 hrs.] Introduction to Energy Targeting, principle of pinch, problem table algorithm, Grand composite curve analysis, Threshold problems, Multiple utility targeting with grand composite curve. Number of units targeting. **Module III:** [8 hrs.] Introduction to area targeting, balanced composite curves, area targeting for unequal heat transfer coefficient, area targeting for equal heat transfer coefficient, shell targeting. **Module IV:** [8 hrs.] Introduction to cost targeting, capital cost targeting, operating cost targeting, total cost targeting, cost targeting for optimum ΔT_{min}. **Module V:** [10 hrs.] Pinch design method for heat exchanger network (HEN) synthesis, rules of pinch design method, remaining problem analysis, design for multiple pinch problem. HEN optimization with case studies.
Text Books, and/or reference material	Suggested Text Books: 1. Ian C. Kemp, Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy, 2nd Edition, ISBN: 9780750682602, Butterworth-Heinemann, 2016. 2. Shenoy U. V.; "Heat Exchanger Network Synthesis", Gulf Publishing Co. 3. Linnhoff B., Townsend D. W., Boland D, Hewitt G. F., Thomas B. E. A., Guy A. R., and Marsland R. H.; "A User Guide on Process Integration for the Efficient Uses of Energy", Inst. Of Chemical Engineers. Suggested Reference Book: 1. Smith R.; "Chemical Process Design", McGraw-Hill.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

Pos / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	-	-	-	-	-	-	-
CO2	3	3	3	3	3	-	-	-	-	-	-	-
CO3	3	3	3	3	3	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO841	CAD for VLSI	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Digital Electronics, Computer Organisation, Algorithm Analysis and Design.		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: To visit the various stages of the VLSI design cycle and appreciate the role of automation therein. • CO2: To appreciate how High Level Synthesis converts an HDL code into an architecture level design. • CO3: To discuss the algorithmic approach to physical design. • CO4: To emphasize the importance to testability measures in the design.						

Topics Covered	VLSI Design cycle. Design styles. System packaging styles. Fabrication of VLSI devices. Design rules-overview. (3L) HLS: Scheduling in High Level Synthesis. ASAP and ALAP schedules. Time constrained and Resource constrained scheduling. (4L) HLS: Allocation and Binding. Datapath Architectures and Allocation tasks. (4L) Partitioning. Clustering techniques. Group Migration algorithms. (4L) Floorplanning. Constraint based Floorplanning. Rectangular Dualization. Hierarchical Tree based methods. Simulated Evolution approaches. Timing Driven floorplanning. (5L) Placement.Simulation based placement algorithms. Partitioning based placement algorithms.ClusterGrowth.(5L) Global Routing. Maze Routing algorithms. Line probe algorithms. Shortest Path based algorithms. Steiner's Tree based algorithms. (5L) Detailed Routing. Channel Routing Algorithms. Switchbox Routing. Over-the-cell routing. Clock and Power Routing. (4L) Design for testability. Fault testing. Ad-hoc and structured DFT techniques.(8L)
Text Books, and/or reference material	**Text Books:** 1. Algorithms for VLSI Physical Design Automation. N.A.Sherwani. Kluwer Academic Publishers. 2. High-Level Synthesis: Introduction to Chip and System Design. Gajski et. al. . Kluwer Academic Publishers. 3. Digital Systems Testing and Testable Design. Abramovici et.al. Jaico Publications. **Reference Books** 1. VLSI Physical Design Automation. Sadiq M. Sait and Habib Youssef. Kluwer Academic Publishers. 2. Algorithms for VLSI Design Automation. Sabih H. Gerez. Wiley India. 3. Essentials of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits. Bushnell and Agrawal. Kluwer Academic Publishers.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	3	3	2	1	-	-	-	2	-
CO2	3	3	3	3	3	-	-	-	-	-	-	-
CO3	3	3	3	3	3	-	-	-	-	-	-	-
CO4	3	3	3	3	2	-	2	-	-	-	1	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 842	Internet and Web Technologies	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Programming Fundamentals, Data Structure and Algorithms, Operating Systems, Data networks (may be carried out		CT+EA [CA: 15%, MT: 25%, ET: 60%]					

simultaneously)	
Course Outcomes	• CO1: Understanding the fundamental concepts of Internet Structure and Protocols. • CO2: Using TCP/IP protocols, SOCKET API and HTTP. • CO4: Designing and developing Web applications with security enhancement. • CO5: Understanding Semantic Web and Applying Web Analytics over Semantic Web.
Topics Covered	INTERNET TECHNOLOGY: Brief review of Data Networking; Introduction to Data Communication, OSI Layered Architecture, Introduction to Networking Devices, Network Performance Metrics. (4L) data transmission over point to point links, link sharing and MACs, Forwarding and Routing, TCP-IP layered network concepts. (3L) Internet specific issues like scalability, inter operability. (1L) Internet Structures – logical and physical grouping with sub netting and super netting. (3L) Review of TCP-IP protocols – processing, performance and variations. (3L) Security Implementations - secured IP, Transport Layer security. (3L) Quality of Service Issues and their Application in Internet. (2L) HTTP: Requests and Responses - Message Formats, Headers and Fields; TCP Keep-alive and pipe-lining concepts; Server Architecture, Performance and Deployment. (3L) WEB PROGRAMMING: Document Object Model; Client side scripting fundamentals: Server Side Scripting and Programming – Data base connectivity, session management and security enhancement; Introduction to Web Application Development Platforms – JavaEE, Dzango. (7L) XML: DTD and Schema; Visualisation using XSLT; Web Application using XML; Service Oriented Architecture and Web services based application development and deployment; Xquery and SOA based application development platforms. (6L) SEMANTIC WEB: General Concept of Semantic Web and linked Data; RDF based relation description; Web Ontology concepts and use; Putting XML, RDF and Ontology together to develop semantic web applications; Capturing Information from semantic web pages; Data analytics over semantic and linked Web. (7L)
Text Books, and/or reference material	**Text Books:** 1. B. A. Forouzan, "TCP/IP Protocol Suite", 4th Edition, 2010, McGrawHIll. 2. P. Deitel, H. Deitel, A Deitel, "Internet and World Wide Web – How to Program", Pearson. 3. G. Antoniou, P. Groth, F. Harmelen and R. Hoekstra, "A Semantic Web Primer" Prentice Hall India. **Reference Books:** 1. D. E. Comer & D L Stevens, "Internetworking with TCP/IP vol.II", Pearson. 2. www.w3schools.com

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	1	1	-	1	-	-	-	2
CO2	2	1	2	-	2	2	1	1	1	-	1	2
CO3	2	2	2	2	3	3	2	3	3	3	1	1
CO4	2	3	2	3	3	3	1	3	3	3	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="8">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSO843</td><td>Soft Computing Techniques</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3">Introduction to computing, Data Structures and Analysis of Algorithms</td><td colspan="5">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand the fundamental concepts, different architectures and learning algorithms for neural networks and its limitations.
• CO2: To introduce evolutionary computing and understanding single and multi-objective genetic algorithms and their applications in optimization problems.
• CO3: To introduce the fuzzy sets, fuzzy logic and fuzzy inference system.
• CO4: To introduce tools and techniques of Soft Computing.
• CO5: To apply soft computing techniques to solve application problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I: Introduction (6L)
Introduction and different definitions of Soft Computing with their application in real life problems, Basic tools/members of Soft Computing: Fuzzy Logic, Neural Network and Evolutionary Computing.
Module II: Fuzzy Logic (12L)
Fuzzy Logic-I: Crisp Sets, Fuzzy sets, Fuzzy membership functions, Basic operations on fuzzy sets, Fuzzy relations and Composition of fuzzy relations.
Fuzzy Logic –II (Fuzzy Rules and Approximate Reasoning): Fuzzy if-then rules: M-A and TSK Rules, Fuzzification, Compositional rule of Inference/Approximate Reasoning, Defuzzification and Applications.
Module III: Neural Networks (10L)
Neural Networks-1 (Introduction & Architecture): Introduction to neural networks: Artificial Neuron and its model, Activation functions, Neural network architecture, learning algorithms/rules, Training and testing.
Neural Networks-II: Perceptron model: single layer and multilayer perceptron (MLP), Error back propagation, Radial basis function network (RBFN), Self-organizing map network (SOMN).
Module IV: Evolutionary Computing (14L)
Evolutionary Computing-I: Evolutionary Computing, Basic concepts and working principle of simple GA (SGA), Genetic Operators: Selection, Crossover and Mutation, flow chart of SGA, Chromosome Encoding & Decoding, Population Initialization, Objective/fitness Function, variable length Chromosome, Introduction to Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Local Search and Memetic algorithm, Application to Travelling Salesman Problem (TSP).
Evolutionary Computing-II: Multi-objective Genetic Algorithm (MOGA)): Conflicting objectives, Objective space and variable space, Domination, Pareto front, Pareto Set, NSGA-II: Non-domination Sorting, Crowding distance operator, Applications.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. S. Rajsekharanand and Vijayalakshmi Pai, “Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications”, Prentice Hall of India.</td></tr>
</table>

2. N. P. Padhy, "Artificial Intelligence and Intelligent Systems", Oxford University Press.
3. G. Klir and B. Yuan, "Fuzzy sets and Fuzzy logic", Prentice Hall of India.
4. K. H. Lee., "First Course on Fuzzy Theory and Applications", Springer-Verlag.
5. G. J. Klir and T. A. Folger: Fuzzy Sets, Uncertainty, and Information, PH.
6. J. Yen and R. Langari, "Fuzzy Logic, Intelligence, Control and Information", Pearson Education.
7. D. Goldberg: Introduction to Genetic Algorithm.

Reference Books:

1. Siman Haykin, "Neural Networks", Prentice Hall of India.
2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications", Wiley India.
3. Kumar Satish, "Neural Networks", Tata Mc. Graw Hill.
4. B. Yegnanarayana , "Artificial Neural Networks"
5. A. Konar, "Computational Intelligence", Springer.
6. Y. H. Pao: Adaptive Pattern Recognition and Neural Networks, Addison-Wesley.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
CO1	2	3	3	3	3	-	-	-	-	-	-	3
CO2	2	3	3	3	3	-	-	-	-	-	-	3
CO3	2	3	3	3	3	-	-	-	-	-	-	3
CO4	3	3	3	3	3	-	-	-	-	-	-	3
CO5	3	3	3	3	3	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO844	Compiler Design	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
CSC-01 (Introduction to Computing)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		• CO1: Understand the fundamental idea of compiler. • CO2: Implement a part of a compiler. • CO3: Know how a compiler recovers from an error.					
Topics Covered		• Introduction to Regular Expressions, NFA and DFA. 3L • Introduction to the philosophy of compilers and course Overview. Introducing different phases of compilers with an example. 1L • Details of Lexical analysis phase. Implementation of a Lexical analyzer. 4L • Regular expression versus Grammars. Different types of Top-Down parsing. Different types of Bottom -up parsing. Implementing one Bottom -up parsing algorithm. 12L • Introduction to Error Recovery Routine, Type Checking and					

	Symbol Table. Introduction to lex and yacc. 4L • Syntax Directed Translation scheme. 6L • Intermediate code generation. Three Address Codes. 5L • Code generation and code optimization. 5L • Linker, Loader 2L
Text Books, and/or reference material	**Text Books:** Compilers: Principles, Techniques, and Tools (Latest Edition). Alfred Aho, Monica Lam, Ravi Sethi, and Jeffrey Ullman. Addison-Wesley **Reference Books:** Engineering a Compiler. Keith Cooper and Linda Torczon. Morgan Kaufman

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	-	-	-	-	-	-	2
CO2	2	2	3	3	3	-	-	-	1	1	3	2
CO3	2	2	2	2	2	-	-	-	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO840	Structronics	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and End Assessment (EA))					
Basic Electronics (ECC01), Engineering Mechanics (XEC01)		Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination					
Course Outcomes	After the completion of the course the student will be able to • **CO 1:** Understand concept of Smart Materials based Electronic Devices • **CO 2:** Apply quantitative analysis techniques to Smart Materials based Electronic Devices • **CO 3:** Understand basic building blocks of Smart Materials based Electronic systems • **CO 4:** Learn design techniques of Smart Materials based Electronic systems • **CO 5:** Investigate application specific Smart Materials based Electronic systems						
Topics Covered	**Module I: Introduction to Smart Materials based Electronic Devices [L-1]** Smart Materials, Smart Materials based Electronic Devices, Applications of Smart Materials based Electronic Devices **Module 2: Characteristics of Smart Materials based Electronic Devices [L-9]** Static, dynamic and quasi static characteristics **of** Smart Materials based Electronic Devices **Module 3: Analysis and Modelling of Smart Materials based Electronic Devices [L-12]** Energy, Co-energy, Energy methods, Hamilton's principle, Lagrange's Equations, Analysis and modelling of Smart material based electromechanical devices **Module 4: Piezoelectric Devices [L-8]** Piezoelectric sensors, actuators, transformers, motors, resonators						

	Module 5: Shape Memory Alloy devices [L-4] Shape Memory effect , Shape Memory Alloy elements, Shape Memory Alloy elements as actuators, Shape Memory Alloy element as sensor **Module 6: Electroactive polymer devices [L-3]** Electroactive polymers, Electroactive polymer actuators **Module 8: Case studies [L-5]** Piezoelectric transducers for ultrasound generation, SMA actuator driven finger exoskeleton
Text Books, and/or reference material	**Text Books:** 1. V. K.Varadan, K.J.Vinoy, S.Gopalakrishnan , *Smart Material Systems and MEMS: Design and Development Methodologie*s, Wiley, 2006 2. J. Bentley, *Principles of measurement systems*. Pearson Education India; 3rd edition, 2002 3. S. H. Crandall, D. C. Karnopp, *Dynamics of Mechanical and Electromechanical*, Medtech Pub, 2017 **Reference books:** 1. D. J. Leo, Engineering Analysis of Smart Material Systems, John Wiley & Sons Inc, 2007 2. A. Preumont *Mechatronics, Dynamics of Electromechanical and Piezoelectric Systems*, Springer, 2011 3. D. K. Gehmlich, S. B. Hammond, *Electromechanical system*, McGraw-Hill, 1967 4. D. Hutton, *Fundamentals of Finite Element Analysis*, McGraw Hill, 2003 5. Research articles

COURSE ARTICULATION MATRIX

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	-	-	-	-	-	-	-	-	-	-	-
CO#2	2	3	-	-	-	-	-	-	-	-	-	-
CO#3	3	2	-	1	-	-	-	-	-	-	-	-
CO#4	3	2	-	1	-	-	-	-	-	-	-	-
CO#5	1	1	-	3	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO841	Signal Processing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous (CT), Mid-Term (MT), End Assessment (EA))					
Signals and Systems (ECC303), Mathematics-II & III (MAC02 & MAC331)		Class Assignments, Mid and End term examinations					
Course Outcomes		**CO#1**. Represent signals in time and frequency domain. **CO#2**. Implement DFT, FFT and z-transform. **CO#3**. Analyse a given signal or system using tools such as Fourier					

	transform and z-transform to know the property of a signal or system. **CO#4**. Design of prototype of Linear Phase Filters, FIR and IIR Filter Structure. **CO#5**. Process signals to make them more useful and to design a signal processor (Digital filter structures) for a given problem.
Topics Covered/ Syllabus	Introduction: reasons behind digital processing of signals, brief historical development, organization of the course. (L=2) Theory of discrete time linear system sequences, linear time invariant systems, causality, stability, difference equations, frequency response, discrete Fourier series, relation between continuous and discrete systems, Inverse Systems, Stability. (L=2) Z –transform: definition, properties of Z transform, system function, digital filter implementation from the system function, region of convergence in the Z plane, determining filter coefficients from the singularity locations, geometric evolution of Z transform in the Z plane, relationship between Fourier transform and Z transform, inverse Z transform. (L=4) Transform technique: Fourier transform, its properties, inverse Fourier transform, discrete Fourier transform, properties of DFT, circular convolution, computations for evaluating the DFT, decimation in time and decimation in frequency FFT algorithms, discrete Hilbert transform. (L=5) Digital filter structures: system describing equations, filter categories, All Pass Filters, Comb Filters, direct form I and II structures, cascade and parallel communication of second order systems, Polyphase representation of filters, linear phase FIR filter structures, Compensatory Transfer Functions, frequency sampling structure for the FIR filter. Test for Stability using All Pass Functions. (L=6) IIR filter design techniques: Analog Filter Design, Analog Butterworth lowpass filter design techniques, Analog Chebyshev LPF, Design methods to convert analog filters into digital filters, frequency transformation for converting lowpass filters into other types, all-pass filters for phase response compensation. (L=6) Digital Filter Structures: IIR Realizations, All Pass Realizations, FIR and IIR Lattice Synthesis, IIR Design by Bilinear Transformation, Digital to Digital Frequency Transformation. (L=6) FIR filter design techniques: Windowing method for designing FIR filters, DFT method for approximating the desired unit sample response, combining DFT and window method for designing FIR filter, frequency sampling method for designing FIR filter (L=6) Non-Linear System Identification Schemes, Fractional-order digital differentiators (DDs) and digital integrators (DIs), Fractional-order low-pass Butterworth and Chebyshev filter. (L=5)
Text Books, and/or Reference material	**Text Books**: 1) Discrete-Time Signal Processing (Second Edition), Alan V. Oppenheim, Ronald W. Schafer, and John R. Buck, Pearson Education India 2) Digital Signal Processing: Principles, Algorithms and Applications (3rd Edition), John G. Proakis, Dimitris G. Manolakis, and D Sharma, Pearson Education India 3) Richard G. Lyons, Understanding Digital Signal Processing, Prentice Hall, 1996. ISBN:0201634678. 4) Digital Signal Processing by Tarun Kumar Rawat, Oxford University Press, ISBN: 9780198081937

	Reference Books: 1) S. W. Smith, The Scientist and Engineer's and Guide to Digital Signal Processing, California Technical Publishing, 1997. ISBN: 0-9660176-3. 2) Digital Signal Processing using MATLAB, Vinay K. Ingle, John G. Proakis, Brooks/Cole-Thomson Learning

COURSE ARTICULATION MATRIX

PO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	2	2	2	1	1	1	1	1	1	1	2
CO#2	3	3	2	2	2	-	1	-	-	1	-	3
CO#3	3	3	2	3	2	1	-	-	1	-	-	3
CO#4	3	3	3	3	2	-	-	1	-	-	-	3
CO#5	3	2	3	3	2	1	1	-	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO842	Introduction to VLSI	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic Electronics (ECC01), Physics of Semiconductor Devices (PHC331)		CT+MT+EA					
Course Outcomes	• CO1: Outline basic knowledge of semiconductor materials, devices and growth process of Si devices • CO2: Identify the process flow of device fabrication. • CO3: Illustrate each process method of VLSI technology • CO4: Build the knowledge of integrated process technology						
Topics Covered	**Module 1: Introduction** [3L] Materials, Definitions, Scaling laws, Idea of Clean room, Si Substrate Growth and Cleaning of Si **Module 2: Oxidation** [5L] Oxidation: Process of Oxidation, Types of Oxidation, Deal-Grove Model, Dependence of oxidation on different parameters, Applications in IC technology, LOCOS. **Module 3: Lithography** [6L] Process flow of lithography, Components of Lithography, Aligner; Contact, Proximity, Projection, Metrics of Lithography, Photo resist-Positive and Negative, Mask, Next generation lithography. **Module 4: Diffusion and Ion Implantation** [7L] Basic Concepts, Diffusion in Si, Poly Si, Basic Process: Pre-deposition and Drive-in Diffusion, Problems in Thermal Diffusion, Advantages of Ion Implantation, Ion Implantation system, Mechanism, Implantation Profile, Junction Depth, Dose and Concentration relationship, Ion Implantation damage and annealing, Ion Channeling, Multi Implantation.						

	Module 5: Thin Film Deposition [6L] Requirements of deposition, Methods: Physical Vapor Deposition and Chemical Vapor deposition, Step Coverage and Filling Issues. **Module 6 Etching:** [3L] Etch process, Requirements, Figure of merits, Types of Etch, Dry and Plasma Etch, Ion enhanced Etch. **Module 7: Metallization and Interconnect** [6L] Interconnect, Interconnect requirements, Possible Interconnect materials, Al metallization, Al spike problem, Hillocks and Voids, Electromigration Problems, Methods to reduce the problems, Metal silicides, Multilevel Metallization, W plugs for contact and vias, Intermetal Dilectrics. **Module 8: IC process Integration** [6L] Simple Resistor, Capacitor, NMOS.
Text Books, and/or reference material	1. VLSI Technology: S M Sze 2. Silicon Process Technology: S K Gandhi 3. Silicon VLSI Technology: Plummer, Deal and Griffin 4. Fundamental of Semiconductor Fabrication: Sze and May

COURSE ARTICULATION MATRIX

PO / CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO# 10	PO# 11	PO# 12
CO#1	1	1	1	1	-	-	-	-	-	-	-	1
CO#2	1	2	1	1	1	-	-	-	-	-	1	1
CO#3	2	3	2	2	-	1	-	-	-	-	1	2
CO#4	3	1	3	-	-	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total number of contact hours = 46				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO843	EMI/EMC	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA)):					
Signals and Systems (ECC303) Analog Communication (ECC401) Digital Communication (ECC501) Electromagnetic Theory and Transmission Lines (ECC403) Microwave Engineering (ECC502)		Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination					
Course Outcomes	**CO#1** Ability to understand the basic knowledge of the sources of electromagnetic interference and electronic equipment classes based on						

	standards **CO#2** Ability to analyze, explain and resolve technical problems related to electromagnetic interference **CO#3** Develop an ability to devise methodologies to mitigate electromagnetic interference and make the electronic system compatible
Topics Covered/ Syllabus	**Introduction to EMI** : Definitions, Different Sources of EMI (Electro-magnetic Interference), Electro-static discharge (ESD), Electro-magnetic pulse (EMP), Lightning, and Mechanism of transferring Electro-magnetic Energy: Radiated emission, radiated susceptibility, conducted emission, and conducted susceptibility, Differential & common mode currents. Concepts of EMC, EMC units. **[L-8]** **Transmission Line Theory** : transmission by guided media, idea of propagation characteristics and computation of VSR, reflection coefficient, scattering parameters. Transients of transmission line, Time-domain Reflectrometry (TDR) basics for determining the properties of a transmission line. Planar Transmission lines Pattern of EM field distribution in a Micro-strip Line, Derivation of Effective Dielectric Constant, Characteristic impedance & Attenuation, Different Micro-strip line design examples, coupled transmission lines, concept of signal integrity **[L-8]** **Impedance Matching & Tuning** : Purpose of Impedance matching, Factors important in the selection of a particular matching network, Different types of Impedance matching, Single stub matching, double stub matching, The quarter-wave transformer, Quarter-wave transformer bandwidth calculation, theory of small reflection, Single-section Transformer, Multi-section Transformer **[L-8]** **Electromagnetic Sensors and Measurement** : Antenna types and their use as sensors, effective height, antenna factor, broadband and multiband electromagnetic sensors, sub wavelength electromagnetic sensors, Power losses in cable, calculation of signal source output for a mismatched load, Measuring & Test systems, Test facilities, measurements of radiated emission in open test range & in Anechoic chamber, Conducted emission testing by Line Impedance Stabilization network (LISN). **[L-8]** **EMC requirements for electronic systems** : World regulatory bodies- FCC, CISPR etc. Class-A devices, class-B devices, Regulations of the bodies on EMC issues. **[L-6]** **Mitigation Techniques Grounding** : Fundamental grounding concepts, Floating ground, Single-point & Multi-point ground, advantages & disadvantages of different grounding processes. Shielding, Cross-talks & Coupling, Measurement set for measuring Cross-talk. Filtering & decoupling. **[L-6]** Electromagnetic pulse and application in warfare, electromagnetic discharge **[L-2]**
Text Books, and/or Reference material	**Text Books:** [1] Clayton R.Paul , *Introduction to Electromagnetic compatibility*- John Wiley & Sons [2] Albert A. Smith Jr., *Radio Frequency Principles and Applications: The Generation, Propagation, and Reception of Signals and Noise*, Wiley-IEEE Press, New York 1998 **Reference Books:** [1] Frederick M Tesche, Michel V.Ianoz, Torbjorn Karlsson, *EMC Analysis Methods & Computational Models*-; John Willey & Sons, Inc [2] Paul G. Huray, *The Foundations of Signal Integrity*, John Wiley & Sons, Inc., 2010

COURSE ARTICULATION MATRIX

PO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	2	1	2	1	2	2	1	1	1	1	1	1
CO#2	2	3	2	2	2	2	1	2	1	2	1	1
CO#3	3	3	3	1	1	2	1	1	2	2	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEO840</td><td>Microgrid systems</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites:</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Acquire an idea about microgrid and its operations.
• CO2: To learn the different components of the microgrid systems.
• CO2: To study different types of microgrid and different control strategies.
• CO3: To model and calculate different parameters of the renewable sources and the energy storage system of microgrid.
• CO4: To learn different active and reactive power control strategies of microgrid.
• CO5: To understand the future applications of microgrid and its role in the electrical ecosystem.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Introduction: What is microgrid, advantage of microgrid over traditional systems, architecture of microgrid, operating modes of microgrid. (2L).
2. Components of microgrid: Local generation, different loads, storage system, converters, filters, monitoring and control system (4L).
3. Classification of microgrid: AC, DC, and hybrid microgrid, architecture and components of different microgrids, classification based on control strategies, centralized and decentralized control (5L).
4. Renewable sources: PV source, modelling of PV source, MPPT of PV source, different components of wind turbine, MPPT control of wind turbine, effect of uncertainty on PV and wind power (6L).
5. Energy storage system: Advantage of ESS, different type, integration of ESS, importance of storage system in microgrid (4L).
6. Microgrid power control: ABC/DQ, DQ/ABC transformation, centralized P-Q control, droop control, master-slave control, peer to peer control (6L).
7. Role of microgrid in future electricity ecosystem: Decarbonisation, digitalization, decentralization, load forecasting, load shedding, energy management. (7L).</td></tr>
<tr><td>Text Books, and/or Reference Material</td><td colspan="7">Text Book:
HANDBOOK ON MICROGRIDS FOR POWER QUALITY AND CONNECTIVITY– Asian Development Bank
Reference Book:
Microgrid Technologies– C.Sharmeela, P.Shivaraman, P.Sanjeevikumar (Wiley)</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	2	2	1	1	1	1	1	1	1
CO2	2	3	3	3	3	1	2	1	2	0	2	1
CO3	2	3	3	3	3	0	2	1	2	0	2	0
CO4	2	3	3	3	3	2	1	1	2	0	2	2
CO5	2	2	2	2	2	1	1	3	2	0	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO841	BIOMEDICAL INSTRUMENTATION!	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO 1: Familiarization with biomedical equipment's and transducers • CO2: Introduction to biomedical signal conditioners • CO3: Acquiring knowledge about development of bio potentials and their measurements. • CO4: Introduction patient health care monitoring • CO5: Introduction to computerized imaging techniques						
Topics Covered	Introduction to biomedical Instrumentation, biomedical electronics, Components of Analog and digital circuits. (8) Various types of signal conditioners, signal conditioning processes. (8) Generation of Nernst Potential, Establishment of diffusion potential, Goldmann Equation, Measurement of membrane potential, resting potential, action potential. (6) Use of electrodes for measurement of bio potentials, polarization in electrodes, principle of operation of Ag/AgCl electrode, Equivalent circuit of electrode. (6) Measurement of ECG, Einthoven triangle method, unipolar and bipolar limb leads, ECG amplifiers, Problems encountered in ECG recording. (6) Introduction to medical imaging, Radiography, Computerized tomography, X Ray, -CT, MRI. (8)						
Text Books, and/or reference material	Text Books: 1. John Enderle. Joseph Brinzino, Introduction to Biomedical Engineering, Elsevier, 2012. 2. John G Webster, Medical Instrumentation, Application & Design, John Wiley & Sons, 2009 Reference Books: 1. L. Cromwell, Fred J. Weibell, Erich A. Pfeiffer, Biomedical Instrumentation & Measurements, PHI, 2014 2. Arthur C Guyton, John E Hall, Textbook of Medical Physiology, Elsevier, 2006:						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	1	1	3	1	1	2
CO2	3	3	3	3	3	3	1	1	3	1	1	2
CO3	3	3	3	3	3	3	1	1	3	1	1	2
CO4	3	3	3	3	3	3	1	1	3	1	1	2
CO5	3	3	3	3	3	3	1	1	3	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEO842</td><td>RENEWABLE ENERGY</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC01 (ELECTRICAL TECHNOLOGY)</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To understand the basics of Energy System and overall energy resources
• CO2: To design the solar and wind power plant
• CO3: To understand the tidal, geothermal energy, biomass and other resources and principles
• CO4: To understand the energy conservation opportunities and energy saving</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Energy system as electrical system, Energy chain, National and International Energy scenario, various non-conventional energy resources-importance, classification relative merits and demerits, Carbon emission, carbon credit, Paris environmental meet for awareness of emission. (9)
Solar photovoltaic: Introduction, solar radiation & its relationship with photovoltaic effect. Photovoltaic concentration, photovoltaic systems-standalone, Solar Constants, Definition of solar thermal: Thermal characteristics of solar radiation, solar collectors: -materials, types, focusing. Solar thermal power plant: layout and arrangement, solar cooling, recent developments. (8)
Wind power and its sources, site selection criterion, wind characteristics, momentum theory, Classification of wind machines. Wind mills-different design & their control, wind generators- different types, wind farms & grid. Wind generation in India. Wind Power and maximum power equation. Wind penetration & its effects, economic issues, recent developments, international scenario. (6)
Principles of tidal power generation, components of power plant, Single and two basin systems, Estimation of energy, Maximum and minimum power ranges. Ocean and geothermal Energy, geothermal power plant. OTEC Principle, Open cycle and closed cycle. (4)
Bio fuel, Conversion of biomass, Biofuel classification, Biomass production for Energy farming, direct combustion for heat-pyrolysis-thermochemical process, Anaerobic digestion- Digester sizing- waste and residues, vegetable oils and biodiesels, Applications of Biogas, Social and environmental aspects. (5)
Fuel Cell: Basic construction & principle of operation of fuel cell, Fuel cell</td></tr>
</table>

	power plants & its integration with wind and solar photovoltaic systems. Geothermal Energy, Dry Steam power plant, Single and Double Flash power plant and integration in electrical system/Grid. (5) Energy conservation opportunities, Type of energy audit, energy audit report. Saving of energy with energy economics. (5)
Text Books, and/or reference material	Text Books: 1. G.D. Rai, Non-conventional energy resources, Khanna Publishers, New Delhi, 2003. 2. N. G. Clavert, Wind Power Principle, their application on small scale, Calvert Technical Press. 3. Fuel Cell Handbook, Parsons Inc. 4. Earnest and T. Wizelius, Wind Power Plants and Projects development, PHI

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1		1	1	1			1	1
CO2	3	3	2	1	1	1	1				1	1
CO3	2	3	3	2	1	1	1	1	1		1	1
CO4	2	3	3	2		1	1	1	1		2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO843	DIGITAL IMAGE PROCESSING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Good understanding of several image enhancement techniques and their application to solve real life problem • CO2: Sufficient expertise in both theory and application of several image processing tasks such as image restoration, image compression, and image segmentation. • CO3: Expertise of several techniques for analysis of images • CO4: Develop basic problem-solving skills as they apply to different situations as an						
Topics Covered	Introduction: Image digitization, Pixel relationship, Distance transformation, Image transformation viz. 2-D DFT, 2-D discrete cosine transform (DCT) (8) Image Enhancement: Point and algebraic operations, edge detection and sharpening, Filtering in the spatial domain, Histogram equalization, Histogram specification, sharpening filters and gradient operators, Introduction to frequency domain filtering using Fourier Transform; Basics of 2D Fourier Transform, Butterworth and Gaussian filters. (10) Image Restoration: Degradation models, Mean Filters, Order Statistics, Adaptive filters, Band reject Filters, Band pass Filters, Notch Filters, Optimum Notch Filtering, Inverse Filtering, Wiener filtering. (6) Color Image Processing: Color image fundamentals - RGB, HSI and CMY models (8)						

	Image Segmentation: Contour and shape dependent feature extraction, textural features, region-based and feature-based segmentation and level set method. (10)
Text Books, and/or reference material	Text Books: 1. Digital Image Processing by Rafael C Gonzalez & Richard E Woods 2. Fundamentals of Digital Image Processing by Anil K Jain 3. Digital Image Processing by William K Pratt

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	2	1	1	2	3	2	2
CO2	3	3	3	2	3	2	1	1	2	3	2	2
CO3	3	3	2	2	2	2	1	1	2	3	2	2
CO4	3	3	3	2	2	2	1	2	2	3	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEO 841	**Nonlinear Dynamical Systems**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NA		CT+EA					
Course Outcomes	CO1: To learn stability analysis of nonlinear transient problems in all fields. CO2: To learn Chaos of nonlinear transient problems using dynamical behaviors (Bifurcations, FFT, Poincare Maps, Lyapunav exponents, Henon maps and Fractals)						
Topics Covered	**One- Dimensional Flow**: Flows on the line, fixed points and stability, linear stability, real life problem and exercises; Flows on circle, Fixed points and stability, real life problem and exercises; Bifurcations: Types of bifurcations, Normal forms of saddle-node, transcritical, pitchfork, Supercritical and Subcritical bifurcations,and imperfect birfercations real life problem and exercises 12 **Two -Dimensional Flows:** Linear system, Definitions and examples, Classification of Linear system, Exercises, Phase plane, Phase portraits, Fixed points and Linearization of nonlinear systems, Exercises, Limit cycles, Definition and understanding with examples, Poincare theory, FFT of time series data, Exercises, Bifurcations of 2-D system, Saddle-node, Transcritical and Pitchfork Bifurcations, Hopf Bifurcations and its type with normal form, Hopf point and fold points, Hysteresis zone, Poincare map, FFT and phase portrait, Exercises 15 **Chaos**: Lorenz Equations, Properties of Lorenz Equations, Lorenz map, Exploring parameter Space, Exercises, One-Dimensional Maps, Fixed points and Cobwebs, Logistic maps, Lyapunov Exponent, Exercises, Fractals, Countable and uncountable sets, Cantor Sets, Dimension of a self, similar Fractals, Box dimension, Point wise Correlation Dimensions, Exercises, Strange attractor, Simplest examples, Henon map, Physical examples, Exercises. 15						

Text Books, and/or reference material	**Text Books:** 1. Nonlinear dynamics and Chaos by S. H. Strogatz
	Reference Books: 1. Chaos and nonlinear dynamics by R. C. Hilborn 2. Differential dynamical systems by J. D. Meiss

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMO841	Material Science	Width Elective	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
PHC01: Engineering Physics, CYC01: Engg Chemistry		CT+EA					
Course Outcomes	CO1: Learn science and technological aspects to a design problem involving materials. CO2: Emphasis is put on such engineering materials which are traditionally and commercially important. CO3: The existing industrial materials problem can be analysed and various techno-economic aspects of materials science.						
Topics Covered	Introduction: Solid Engineering Materials- their classification and characteristic properties.(1) Solidification of pure metals: Homogeneous and Heterogeneous nucleation process, cooling curve, concept of supercooling, microstructures of pure metals. (1) Binary phase diagrams: Isomorphous, eutectic, eutectoid, peritectic, and peritectoid systems, effect of non-equilibrium cooling, coring and homogenization. (2) Iron cementite diagram: Construction and interpretation of Fe-Fe_3C and Fe Graphite diagrams. Microstructure and properties of different alloys in steel and cast iron, their microstructures and typical uses. (2) Physical metallurgy of common non-ferrous alloys: Cu, Al and Ni based alloys. Microstructures and heat treatment of common alloys of these systems. (2) Study of the industrially important steels, their mechanical and thermal treatment and uses: Plain carbon steels, Dual Phase Steels and High Strength Low alloys (HSLA) Steels. (8) Effect of Alloying Elements in Steel. Alloy Steels: Manganese Steels, Hadfield manganese Steel. Heat Resistant and Stainless Steels, Tool and Die Steels, High speed tool steel (HSTS), Maraging Steels. (7) Study of Nonferrous Alloys, their mechanical and thermal treatment: Brasses, Bronzes, Bearing Metals, Light alloys based on Aluminium and Magneium, Titanium Base alloys, Ni base alloys, Lead and tin base babbits. (8) Cryogenic and High temperature Materials, Alloy cast irons, Special purpose materials, such as, Materials for Aerospace, Nuclear Reactors etc. Electrical and Magnetic Materials. (4)						
Text Books, and/or reference material	Text Books: 1. W. D. Callister, Materials Science and Engineering an Introduction, Wiley, 2003. 2. V. Raghavan, Materials Science and Engineering, PHI, New Delhi, (1998). 3. An Introduction to Physical Metallurgy – S. N. Avner, McGraw-Hill. 4. Structure and properties of materials – J Wulff and other. Vols. I–IV. Wiley Eastern pub Ltd. New Delhi 5. Metallurgy for Engineers – E C Rollason 6. Physical Metallurgy – Vijendra Singh. 7. Engineering Materials: H. J. Sharp Haywood, London (1961)						

	8. Engineering Materials: M. F. Ashby and D. R. N. jones, Pergamon press (1980). Reference books: 1. Materials Science and Engineering by Raghavan - Prenctice Hall of India Ltd. 2. Physical Metallurgy of Engineering Materials by N. R. petty, Allen Unwin (1968) 3. Light Alloys: Metallurgy of the light Metals by I. J. Polmser-Edwaraed annord. The Super alloys by C. T. Sims and W. C. Hegel –Wily-Interscience.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	3	2	2	2	2	3	2	1	1	1
CO2	1	2	3	1	2	1	2	3	2	1	2	1
CO3	1	1	3	2	2	1	1	3	2	1	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

BASKET – 5

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO850	International Economics and Globalization	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: Have a good conceptual understanding of the key concepts and practical applications of international trade and globalization. CO2: Outline the development trade theory historically, differentiating standard classical and orthodox trade theories. CO3: Analyze the links between trade, international finance, economic growth and globalization, with a particular emphasis on the experiences of developing countries. CO4: Critically comment on and participate in current debates on international economic policy.						
Topics Covered	Unit 1: International Trade: Classical Theory -(3 L) Unit 2: International Trade: H-O Theorem -(3 L) Unit 3: International Trade: Factor Endowment Theorem -(3 L) Unit 4: International Trade Policy: Instruments -(3 L) Unit 5: Tariff and Protection -(3 L) Unit 6: Export Subsidy and Import Quota -(3 L) Unit 7: International Monetary Economics: Basics -(3 L) Unit 8: International Monetary Economics: Balance of Payments, Foreign trade Multiplier -(3 L) Unit 9: International Monetary Economics: Devaluation & Absorption Approach -(3 L) Unit 10: International Monetary System: fixed vs. flexible regime -(3 L) Unit 11: International Monetary System: Gold Exchange -(3 L) Unit 12: International Monetary System: IMF and World Bank -(3 L) Unit 13: Globalization -(3 L) Unit 14: Liberalization in Indian Economy -(3 L)						
Text Books, and/or reference material	1. Krugman and Obstfeld, International Economics 2. Sodersten& Reed-International Economics 3. Salvatore – International Economics 4. Mishra & Puri- Indian Economy 5. Datta &Sundaram- Indian Economy 6. Sunanda Sen – Globalization and Development						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	2	2	3	3	3	2	3	3	3
CO2	2	3	3	2	2	3	3	3	2	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	2	3	3	2	2	3	3	3	2	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO851	Literature and Cinema	POEL	42	0	0	42	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: To develop students' understanding of texts and their cinematic adaptations. • CO2: To undertake detailed studies as well as analyses of changes or alterations during the conversion of one art-form into another. • CO3: To delve deeper into the relevance, future and scope of cinematic adaptations.						
Topics Covered	• Differences and similarities between Literature and Cinema. (4) • Basics of Cinematic Adaptations (3) • The development of cinematic language as visual narration. (4) • Close reading/watching, analysis, and discussion on Cinematic adaptation I (4) • Close reading/watching, analysis, and discussion on Cinematic adaptation II(4) • Close reading/watching, analysis, and discussion on Cinematic adaptation III(4) • Close reading/watching, analysis, and discussion on Cinematic adaptation IV(4) • Close reading/watching, analysis, and discussion on Cinematic adaptation V(4) • Adaptation/Appropriation /Adulteration (8) • Future of Literature and Cinema (3)						
Text Books, and/or reference material	Suggested Text Books: 1. The Home and the World – Rabindranath Tagore 2. Othello – William Shakespeare 3. Five Point Someone –Chetan Bhagat Suggested Reference Books: 1. Bluestone, George. *Novels into Film*, the John Hopkins Univ Press. 2003. 2. Mandal, Somdatta, *Film and Fiction: Word into Image*, Rawat 2005. 3. Rai, Shri Krishan, and A Raieds. *Adaptations: Some Journeys fromWords toVisuals*, Cambridge Scholars Publishing, 2015. 4. Stam, Robert. *Film Theory: An Introduction*. Oxford Blackwell, 2000.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		2				3	2	2	3	3		2
CO2		3		2		3	2	2	3	3		2
CO3		2	2		2	3			3	2		3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Humanities & Social Sciences</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>HSO852</td><td>Classics of Literature</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Learners will be acquainted with the variegated aspects of life represented through literature
• CO2: Learners will be able to critically appreciate a piece of literary work acknowledged to be a classic
• CO3: Learners will be introduced to the sublime beauty of literary language</td></tr>
<tr><td>Topics Covered</td><td colspan="7">. <u>Poetry (any five to be selected by the Instructor)</u>:
William Shakespeare: Sonnet No. 73/ Sonnet No. 116 / Sonnet No. 118
John Donne: The Canonization / The Extasie
Andrew Marvell: To His Coy Mistress / The Garden
William Wordsworh: Upon Westminster Bridge / Tintern Abbey
P. B. Shelley: The Cloud / Ode to the West Wind
John Keats: Ode on a Grecian Urn/ Ode to a Nightingale / Bright Star
Lord Alfred Tennyson: Break, Break, Break / Ulysses / Tithonus
Robert Browning: My Last Duchess / Two in the Campagna
Matthew Arnold: Shakespeare / Dover Beach
W. B. Yeats: The Second Coming /Sailing to Byzantium
T. S. Eliot: The Love Song of J. Alfred Prufrock /Preludes
B. <u>Play (one to be selected by the Instructor)</u>:
Christopher Marlowe: Doctor Faustus / William Shakespeare: Julius Caesar / William Shakespeare: Macbeth / William Shakespeare: Hamlet / William Shakespeare: Othello / William Shakespeare: King Lear /William Shakespeare: As You Like It / William Shakespeare: Twelfth Knight /Bernard Shaw: Arms and the Man / Girish Karnad: Hayavadana /John Galsworthy: Justice / St. John Ervine: Progress / T.S. Eliot: Murder in the Cathedral / Samuel Beckett: Waiting for Godot / John Osborne: Look Back in Anger / Harold Pinter: The Birthday Party
C. <u>Novel (one to be selected by the Instructor)</u>:
Charles Dickens: Hard Times / Thomas Hardy: The Mayor of Casterbridge / E M Forster: A Passage to India / Joseph Conrad: Heart of Darkness / William Golding: Lord of the Flies / Graham Greene: The Power and the Glory / James Joyce: A Portrait of the Artist as a Young Man/ George Orwell: Animal Farm</td></tr>
<tr><td>Text and/or Books</td><td colspan="7">Text Book:
As recommended by the Instructor from time to time</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1	-	3	3	3	3	3	2	3
CO2	1	3	2	2	1	-	-	1	-	3	-	3
CO3	1	-	-	-	-	-	3	-	-	3	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Humanities & Social Sciences</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>HSO853</td><td>Public Speaking</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td colspan="3">Course Outcomes</td><td colspan="5">• CO1: Learners will have a good grasp of the basic skills to present a speech that is effective, natural, and beneficial for both the speaker and the audience.
• CO2: Learners will develop their communicative skills and the ability to connect deeply with another human being on the societal plane.
• CO3: Learners will be equipped with a basic understanding of speech research, organisation, and delivery.</td></tr>
<tr><td colspan="3">Topics Covered</td><td colspan="5">1. Communicating with Others (4)
2. Giving Yourself Permission (4)
3. Organising Your Speech (4)
4. Selecting Your Topic (4)
5. Gathering Your Material (4)
6. Listening to Others (4)
7. Delivering Your Speech (4)
8. Informing Your Audience (5)
9. Persuading Your Audience (5)
10. Speaking for Your Lifetime (4)</td></tr>
<tr><td colspan="3">Text Books, and/or reference material</td><td colspan="5">Text Book:
1. The Natural Speaker. 8th Edition. Randy Fujishin. Routledge.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	2	-	-	-	2	3	1	-	3
CO2	1	-	-	2	-	3	3	2	-	3	-	3
CO3	2	1	1	2	3	-	-	-	-	2	1	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

DEPARTMENT OF MANAGEMENT STUDIES							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MSO851	INVESTMENT MANAGEMENT AND STOCK MARKET	PEL	3	0	0	3	3
Pre-requisites- NIL		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1: To learn about investment decision process and various investment avenues CO2: To understand about Stock / capital market CO3: To learn about equity valuation tools and techniques CO4: Portfolio Management process and risk and return analysis						
Topics Covered	**UNIT I:** Introduction to various investment avenues and alternatives, Investment vs gambling and speculation, Types of investors and avenues, New Issue market and Stock Exchanges, Trading mechanisms in stock exchange- **(5)** **UNIT II:** Equity Valuation: Macroeconomic Analysis Industry Analysis; Company Analysis; Valuation of Equity Shares- (10) **UNIT III:** Fixed Income Security Analysis: Bond Prices and Yield (3) **UNIT IV:** Technical Analysis (6) **UNIT V:** C Risk Vs Return Efficient Market Hypothesis. Capital Market Theories: CAPM, CML, SML, Efficient frontier with Riskless lending and borrowing, Markowitz Model, Sharpe single index Model) Portfolio Risk & Return Factor Models and Arbitrage Pricing Theory (8) **UNIT VI**: Portfolio Management -Portfolio Evaluation and Behavioural Finance Portfolio revision (2) **Unit VII**- Derivatives Market (6)						
Text Books, and/or reference material	Text Books: 1. Investment Analysis and portfolio Management- P Chandra TMH 2. Security Analysis and Portfolio Management - Donald E. Fischer, Ronald J. Jordan 3. Value investing and Behavioural Finance, Parikh, TMH 4. Investment Management – V.K. Bhalla – S. Chand 5. Investment Management and Security Analysis – D.K. Khatri – Mcmillan						

Department of Management Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MSO 852	INDUSTRIAL MARKETING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA)					
NIL		CT+EA					
Course Outcomes	• CO1: Understand the importance of industrial marketing • CO2: Analyse industrial consumer behaviour						

	• CO3: Formulate effective industrial marketing strategies
Topics Covered	1. Understanding industrial marketing Company's vision and industrial marketing, market paradigms, business assumptions, understanding industrial customer orientation, the customer-product relationship, customer orientation through the product, competitive behaviour in industrial markets (10). 2. Understanding industrial products What is an industrial product? Types of industrial product, nature of industrial product, commodity marketing, industrial product functionality, industrial product life cycle (5). 3. Exploring industrial markets Identifying industrial consumer need, purchase behaviour of an industrial customer, industrial purchasing process, factors influencing industrial purchase decisions, industrial marketing research process (5). 4. Industrial market segmentation Need for segmentation, different bases of segmenting industrial markets, process of segmentation of industrial markets (3). 5. Industrial product design and development Turning customer needs into product/service, process of product development, adoption process of industrial products (3). 6. Organizing marketing and sales department of an industrial company Organizational structure of an industrial sales force, organizational structure of an industrial marketing department, cross-selling industrial products (3). 7. Industrial sales force Purpose of an industrial sales force, industrial selling process, role of a sales engineer, consultative sales management for complex industrial products, industrial sales force compensation (3). 8. Distribution of industrial products Characteristics of industrial distribution, types of industrial distribution, key issues in designing industrial distribution (3). 9. Industrial branding Different types of industrial brands, factors affecting industrial branding, principles of industrial branding (2) 10. Pricing industrial products Challenges in industrial price management, a general model for price determination of industrial products, key issues in value based pricing (3). 11. Promotion strategies for industrial products Advertising, the COMPACT model, other forms of promotion strategies for industrial products (2).
	Text Book: The Marketing Challenge for Industrial Companies: Advance Concepts and Practices, Claudio A Saavedra, Springer, 2016. Reference Books: 1. Industrial Marketing, P. K. Ghosh, Oxford University Press, 2005. 2. Industrial Marketing, Ronald McTavish and Angus Maitland, The Macmillan Press, 1980

CO-PO mapping matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO#1											2	3
CO#2				1					2		2	3
CO#3						2			2		2	3

<table>
<tr><td colspan="7">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td>Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td><td></td></tr>
<tr><td>MAO851</td><td>Operations Research</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Basic concepts of Set Theory, Linear Programming Problem, Network and Game Theory</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• CO1: To understand the origin of Operations Research and &to familiarise with formulation of different Problems.
• CO2: To acquire knowledge on fundamentals of Linear Programming and also to learn its applications.
• CO3: To get basic knowledge on fundamentals of Netwok Analysis so as to get acquainted with designing & planning of various project related problems.
• CO4: To get the basic Concepts of decision making under competitive situations.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Overview of Operations Research: Origin of OR and its definitions, Formulation of the OR problems, Developing OR models, Testing the adequacy of the model, Model solution, Evaluation of the solution and implementation. (4)
Linear Programming and its Applications: Vector spaces, Basis, Linear transformations, Convex sets, Extreme points and convex polyhedral sets Theory of Simplex method, Simplex Algorithm, Degeneracy, Duality theory, primal dual algorithms, Transportation problems, Assignment problems, Sensitivity analysis. (14)
Network Analysis: Introduction to network analysis, Shortest path problem, Construction of minimal spanning tree, Flows in networks, Maximal flow problems. Definition of a project, Job and events, Construction of arrow diagrams, Determination of critical paths and calculation of floats. Resource allocation and least cost planning, Use of network flows for least cost planning. Uncertain duration and PERT, PERT COST system. Crashing. (12)
Game Theory: Maxmin and Minmax principle, Two-person Zero-sum games with saddle point, Game problems without saddle point, Pure strategy and mixed strategy, Solution of a 2×2 game problem without saddle point, Graphical method of solution for n×2 and 2×n game problem, Reduction rule of a game problem (Dominance rule), Algebraic method of solution of game problem without saddle point, Reduction of a game problem to linear programming problem. (12)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">Text Books:
1. J. K. Sharma: Fundamentals of Operations Research, Macmillan.
2. F.S. Hiller and G. J. Leiberman, Introduction to Operations Research (6th Edition), McGraw-Hill International Edition, 1995.
3. Ravindran, Philips, Solberg, Operations Research Principles and Practices, Wiley India Edition.
Reference Books:
Kanti Swarup, P. K. Gupta and Man Mohan, Operations Research- An Introduction, S. Chand & Company.
2. Anderson, D. R., Sweeney, D. J. and Williams, T. A., An Introduction to Management Science, St. Paul West Publishing Company, 1982.
3. Sharma, S. D., Operations Research, Kedar Nath & Ram Nath, Meerut, 1995.
4. H. A. Taha, Operations Research –An introduction, PHI</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
MAO851	CO1	2	3	2	2	1	1	1	-	-	-	1	2
	CO2	2	3	2	1	1	2	2	-	1	2	2	2
	CO3	3	3	2	3	1	-	1	-	2	2	2	2
	CO4	2	2	3	1	2	2	2	1	2	2	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total contact hours (Per week)				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAO852	Advanced Numerical Analysis	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basics of Linear Algebra & Numerical Methods		CT+EA					
Course Outcomes	• CO1: Develop problem solving skills by different numerical methods and also skill in numerically verifying theoretical convergence speed. • CO2: Help to work with key concepts of stability and assessing the accuracy of numerical results. • CO3: Help to write algorithm, computational steps & flow chart which help in developing computer program. • CO4: Help to solve various scientific and engineering problems by different numerical methods.						
Topics Covered (with lecture hours)	Numerical solution of Algebraic and transcendental equations (Method of Iteration, Newton-Raphson method), convergence and errors. (3) Solution of system of equations by Direct method (Gauss-elimination, Gauss Jordon, L-U decomposition) and Iteration method (Jacobi, Gauss-Seidel), Convergence analysis and errors. (7) Eigen values and Eigen vectors by power method. (3) Interpolation- Newton's divided difference, cubic spline, Hermite poly, error in interpolation, Least square approximation. (6) Numerical differentiation and integration (Trapezoidal rule, Simpson's $1/3^{rd}$ rule, Simpson's $3/8^{th}$ rule), Error analysis. (5) Numerical solution of ordinary differential equations (Taylor series method, Euler's & Modified Euler's method, Runge-Kutta method), Finite difference solution of boundary value problem. (9) Numerical solution of partial differential equations of hyperbolic (wave equation), parabolic (heat equation), elliptic (Laplace and Poisson equation)(9)						
Text Books, and/or reference books	**Text Books:** 1. Introductory Methods of Numerical Analysis- S.S.Sastry (PHI). 2. Numerical Methods for scientific & Engineering Computation- M.K. Jain, S.R.K. Iyengar & R.K. Jain (New Age International (P) Ltd.). **Reference Books:** 1. Numerical Mathematical Analysis- J.B. Scarborough (Oxford & IBH). **2.** A friendly introduction to Numerical Analysis, Braine Bradie, Pearson Edu.						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO 1	PO 2	PO 3	PO4	PO5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
MAO8 52	CO1	3	3	2	2	3	1	2	-	-	3	1	2
	CO2	2	3	2	2	1	2	1	1	1	2	1	2
	CO3	2	2	1	1	-	-	1	-	-	1	-	2
	CO4	3	2	2	2	2	2	2	-	2	3	2	3

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAO853	Optimization Techniques	PEL	3	0	0	3	3
Pre-requisites		Vector Spaces and Matrices, Linear Transformations, Eigenvalues and Eigenvectors					
Course Outcomes		• CO1: Ability to develop a knowledge in the field of optimization techniques and their basic concepts, principles and algorithms. • CO2: Ability to understand fundamentals of linear programming, Integer programming and Dynamic programming. • CO3: Ability to apply the theory of optimization methods for modelling various types of decision making problems. • CO4: Ability to solve the mathematical results and numerical algorithms of optimization theory to concrete Engineering and Management problems.					
Topics Covered		**Basic Concepts:** Formulation of mathematical programming problems; Classification of optimization problems; Optimization techniques – classical and advanced techniques (5) **Optimization using Calculus:** Convexity and concavity of functions of one and two variables; Optimization of function of multiple variables subject to equality constraints; Lagrangian function; Optimization of function of multiple variables subject to equality constraints; Hessian matrix formulation (7) **Linear Programming:** Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Graphical method for two variable optimization problem; Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Revised simplex method; Duality in LP; Primal dual relations; Dual Simplex Method; Sensitivity or post optimality analysis; bounded variables; Examples for transportation, assignment, TSP problems. (18) **Dynamic Programming:** Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality (8) **Integer Programming:** Integer linear programming; Branch and Bound algorithm; Concept of cutting plane method; Mixed integer programming; Solution algorithms. (8) **Advanced Topics in Optimization:** Direct and indirect search methods; Heuristic and Meta-Heuristic Search methods; Multi objective optimization. (10)					

Text Books, and/or reference material	**Text Books:** 1. Singiresu S. Rao, *Engineering Optimization -Theory and Practice,* New Age International (P) Limited, New Delhi, 2000. 2. H.A. Taha, *Operations Research: An Introduction*, 5th Edition, Macmillan, New York, 1992. A. Ravindran, K. M. Ragsdell and G. V. Reklaitis, *Engineering Optimization-Methods and Applications,* Wiley-India Edition, New Delhi, 2002. **Reference Books:** 1. R. Fletcher, *Optimization,* Academic Press, 1969. 2. 2. K. Deb, *Optimization for Engineering Design Algorithms and Examples*, Prentice-Hall of India Pvt. Ltd., New Delhi, 1995.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
MAO853	CO1	2	3	3	2	1	1	2	-	1	-	1	1
	CO2	2	2	3	1	2	-	3	-	1	-	2	1
	CO3	3	2	2	2	2	-	2	-	1	1	2	2
	CO4	3	2	3	3	2	-	3	-	1	1	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHO 851	**Fiber-Optics Communication**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	After completion of the course, the student is able to **CO1:** Distinguish and identify different types of fibers and there potential application in different fields of optical communication and sensing. **CO2:** Explain different characteristics of optical fiber along with dispersion and attenuation. **CO3:** Understand and classify the working principle of different optical sources and detectors. **CO4:** Acquire basic knowledge of short haul, long haul and advanced optical transmission systems.						
Topics Covered	**Introduction to Optical Fiber Communications:** Transmission speed, Evolution of Fiber Optic Systems, Elements of an Optical Fiber Transmission Link. [3] **Optical Fibers: Structures, Waveguide and Fabrication:** Ray propagation through SI and GI fiber, Pulse broadening- multipath dispersion and material dispersion, Maxwell's Equations, TE and TM mode wave equations. Wave propagation in rectangular slab and circular waveguides, Propagation modes, Power Flow in rectangular slab waveguide, Single-mode fibers; Mode-field diameter. Fiber fabrication; overview of different methods of fabrication. [14]						

	Signal Degradation in Optical Fibers: Signal attenuation, Absorption, Scattering Losses, Bending Losses, Core and cladding losses, coupling loss. Group Velocity Dispersion, Material Dispersion, Waveguide Dispersion, Polarization-Mode dispersion, Intermodal Distortion. **[7]** **Optical Sources and Detectors:** Review of semiconductor Physics. Light Emitting Diodes (LEDs); Structure, Materials, Quantum Efficiency and LED Power, Modulation of an LED. Laser Diodes; Threshold conditions, Rate equations, Quantum efficiency, Resonant frequencies, Structure and radiation patterns, Single-mode lasers, Modulation, Effects of temperature. Optical detectors- p-n junction, P-I-N, APD, Phototransistor, PMT detectors. [12] **Power launching and coupling:** Source-to-Fiber power launching lensing schemes for coupling improvement, Fiber splicing, Optical fiber connectors and optical devices, etc. [6]
Text Books, and/or reference material	**TEXT BOOKS:** **1.** Fiber Optics and Optoelectronics, R. P. Khare, Oxford University Press 2. Optical Fiber Communications (3rd Ed.), Gerd Keiser- McGraw-Hill 3. Optoelectronics Photonics , S.O. Kasap **REFERENCE BOOKS:** 1. Introduction to Fiber Optics, Ajoy Ghatak & K. Thyagarajan, Cambridge University Press 2. Fiber-Optic Communications Technology, D. K. Mynbaev & L. L. Scheiner, Pearson Education 3. Optical Communication Components & Systems, J. H. Franz & V. K. Jain.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
PHO 851	CO1	3	1	1	1		2	2	1	1	1	1	1
	CO2	2	2	2	1	1	1	1	1	1	1	1	2
	CO3	2	2	3	2	2	1	1	1	2	1	1	1
	CO4	2	2	2	1	1	1	1	1	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHO852	**Optical Instrumentation**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: To realize fundamental concepts of optics such as reflection, refraction and diffraction in designing optical elements. CO2: To learn basics and working principle of some optoelectronic devices. CO3: To gain an integrative overview and applications of different optical microscopes, telescopes and spectroscopes.						

	CO4: To acquire fundamental knowledge of interferometry and apply it in optical metrology.
Topics Covered	**Optical elements**: Reflective and Refractive optical elements, Diffractive optical element, Holographic Optical Element, Grating, Prism. [6] **Microscopy**: Bright field microscopy, Dark field microscopy, Phase-Contrast microscopy, Polarized light microscopy, Differential Interference contrast microscopy, Fluorescence microscopy, Confocal microscopy, Digital Holographic microscopy. [8] **Spectroscopy:** Atomic Absorption Spectroscopy, UV-Vis-NIR Spectroscopy. [4] **Optical Interferometer:** Common path interferometer, Multiple-Beam interferometer, Multiple wavelength interferometer, Shearing interferometer, Speckle interferometer. [6] **Optoelectronic devices**: Photomultiplier Tubes, Photodiodes, CCD, acousto-optic modulator, electro optic modulator [6] **Optical Instruments**: Optical Coherence Tomography, Particle Image Velocimetry. [6] **Optical Metrology**: Moire, fringe projection, Holography and Speckle techniques. [6]
Text Books, and/or reference material	**TEXT BOOKS** 1. Optical Shop Testing, D. Malakara, Wiley & Sons, Inc. 2007. 2. Practical Holography, G. Saxby, CRC Press, 2017. 3. Materials Characterization, Yang Lang, Wiley-VCH, 2013. **REFERENCE BOOKS** 1. Fundamental of Photonics, B. E. A. Saleh, M. C. Teich, Wiley, 2007. 2. Optics, E. Hecht, Addison-Wesley, 2001. 3. Optics, A. Ghatak, Tata McGrawHill, 2005.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
PHO 852	CO1	3	2	2	2	1	1	1	1	1		1	1
	CO2	3	1		1	1							1
	CO3	3	2	2	2	1	1	1	1	1		1	1
	CO4	3	2	2	2	2	1	1	1	1		1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO850	Medical Biotechnology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	· CO1: To provide an understanding about Inborn errors of metabolism and genetic disorders and their consequence. · CO2: Able to analyze the key features therapeutics and drugs in current scenario. · CO3: Able to apply the knowledge for commercial production of pharmaceuticals and place it in market for marketing approvals. · CO4: Able to understand the ethical issues and the different competent regulatory authorities globally associated with clinical Biotechnology.
Topics Covered	**Microbial pathogenesis:** Definitions - Infection, Invasion, Pathogen,Pathogenicity, Virulence, Carriers and their types, Opportunistic infections, NosocomialInfections, epidemics. **Diagnosis of Infectious diseases**–Biology of Nitric oxide implications in diagnosis and therapeutics, Ethical problems around prenatal diagnosis, *in vitro* fertilization, cloning, gene therapy. **DrugDesign and Drug delivery system:** Synthesis of compounds in accordance with the molecular structure and biological activity concept. Various principles/ mode of drug action/ screening of drugs/ drug analysis using various techniques. New generation viral vectors for Gene Therapy and advancement in Drug Delivery system, antibody mediated drug delivery of vaccines, Antibiotics **Molecular Medicine:** Antibodies and vaccines-Therapeutic production of antibodies, different kind of vaccines and applications of recombinant vaccines.Ribozymes for therapeutic use in viral infection. **Cell and tissue therapy** – Gene therapy, tissue engineering, stem cell and cloning. In vivo targeted gene delivery **Clinical Toxicology**,**Clinical Research Governance and Ethics:** Basic concept in toxicology. Types and mechanism of toxin action-Epoxidation & drug toxicity, Overview on regulatory affairs for pharmaceuticals, neutraceuticals and medical devices. . International quality standard and related guidelines (ICH-E6). Risk assessment and trial monitoring. Legal and ethical issues on biotechnology, medical research and related clinical practice.
Text Books, and/or reference material	Suggested Text Books: 1. Recombinant DNA: Genes and Genomes - A Short Course, Third Edition (Watson, Recombinant DNA) by James D. Watson; Cold Spring Harbor Laboratory Press 2. Biopharmaceuticals- Biochemistry and Biotechnology: Gary Walsh; John Wiley & Sons 3. S. P. Vyas, V. Dixit, Pharmaceutical Biotechnology, CBS Publishers 4. Cedric A and Mim S. et al.: Medical Microbiology, Mosby USA Suggested Reference Books: 1. Pharmaceutical Biotechnology ; Sambhamurthy&Kar , NewAge Publishers 2. Epenetos A.A.(ed), Monoclonal antibodies: applications in clinical oncology, Chapman and Hall Medical, London 3. V.Venkatesharalu -Biopharmaceutics and Pharmacokinetics-Pharma Books Syndicate 4. Diagnosis: A Symptom-Based Approach in Internal Medicine; C.S.Madgaonkar, Publisher: JPB

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	2	2	1	-	-	-	-	-	2
CO2	2	1	1	-	1	1	-	1	-	1	-	2
CO3	2	1	1	1	1	1	-	1	-	1	1	2
CO4	2	1	1	1	1	2	2	2	1	1	2	2

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO850	**Watershed planning & Management**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Fluid Mechanics, Irrigation & Water Resources Engineering, Economics and Computer Applications	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	· CO1: A clear understanding of different aspects of watershed · CO2: Development of capabilities for optimization techniques, linear and dynamic programming for watershed management · CO3: Development of ability to formulate model for watershed planning with deterministic as well as stochastic inputs,
Topics Covered (Hrs)	**Introduction**: Concept, Definition & Scope, Indian & Global Perspective, Timeline in India, Problems & Prospects, Problems & Constraints **(4)** **Land Capability & Planning**: Definition, Classification, Planning, Use, Restoration, Policy Analysis & Decision Support **(3)** **Watershed Characteristics:** Physical & Geomorphologic Factors, Classification & Measurement, Physical, Geomorphologic & Quantitative Characteristics **(4)** **Importance of Watershed Properties:** Watershed Management, Effect of Physical Properties, Effect of Geomorphologic Factors & Associated Processes **(4)** **Hydrologic Data**: Definition, Scope, Hydro-meteorological & Physiographical Data **(3)** **Delineation and Prioritization**: Concept of Topographic or Contour Map, Boundary Delineation, GIS for Delineation, Accuracy in Delineation, Concept of Priority, Factors, Basics & Methods, Purpose & Benefits **(4)** **Water Yield Assessment & Measurement**: Concept of Water Yield & its assessment, benefits, Perspectives, Measurement, Modelling & Assessment **(3)** **Hydrologic and Hydraulic Design**: Hydrologic design, recharge structures, Earthen Embankments & Diversion Structures, Hydrology & Hydrologic design **(5)** **Soil Erosion and its Control Measures**: Types, Problem & Control **(4)** **Sediment Yield Estimation**: Generation & Transport Mechanism, Types Methods Estimation & Modelling, Estimation of Different Load **(4)**

	Rainwater Conservation & Harvesting: Need, Techniques, Design **(4)**
Text Books, and/or reference material (s)	***Text Books:*** 1. Watershed management challenges: Introduction and overview by E. R. Sharma & C. A. Scott, (2005), Watershed Management Challenges: Improving 2. Land and Water Management Engineering by V. V. N. Murthy & M. K. Jha, (2011), Kalyani Publishers, Ludhiana, India. 3. Watershed Management- Guidelines for Indian Conditions by E. M. Tideman, (1999), Omega Scientific Publishers, New Delhi. 4. Integrated Watershed Management in Rainfed Agriculture by S. P. Wani, J. Rockström & K. L. Sahrawat, (2011). CRC Press. ***Reference Books:*** 5. http://www.ussi.co.uk/Weirs_and_Flumes.html. Last seen: 29th September 2013

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO9	PO10	PO11	PO1 2
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	3	3	3	3	3	-	-	-	-	-
CO3	-	-	3	-	-	-	-	3	3	3	3	3

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO851	**Elementary Structural Design**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Engineering /Solid Mechanics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	· CO1: Apply knowledge of solid mechanics for design solutions. · CO2: Understand basic design philosophy applicable to steel structures. · CO3: Formulate, analyze, and design basic components of Civil Engineering Steel structures.
Topics Covered (Hrs)	**Properties** of Reinforced Concrete and Structural Steel, Loads & load combinations, Design Philosophies-Working Stress Method, Limit State Method **(4)** **Limit State Method (LSM) of design for RC Structures:** Limit State of Flexure: Stress-strain characteristics of concrete & reinforcing steel, Moment of Resistance for singly reinforced, doubly reinforced sections. Limit State of Shear, Bond & Anchorage, Development length, Design of Beams, slab, Short Columns under axial load, Design of isolated Footing. **(19)**

	Limit State Method (LSM) of design for Steel Structures: Limit state of collapse & serviceability, partial safety factor for material and loading, Connections: truss joint connections, Design of Tension member, Compression member, Design for Beams, Gusseted Column base foundation **(19)**
Text Books, and/or reference material (s)	***Text Books:*** 1. Reinforced Concrete Design by S. U Pillai and Devdas Menon, Tata McGraw-Hill. 2. IS 456: 2000, Indian Standard Plain and Reinforced Concrete – Code of Practice (4th Revision), BIS, New Delhi. 3. Design of steel Structures by N. Subrhamanium (Oxford publications) 4. IS 800-2007: General Construction in Steel-Code of Practice 5. IS 808-1989: Dim of Hot Rolled Steel beam, column, channel and angle sections 6. www.nptel.iitm.ac.in/courses/ ***Reference Books:*** *7.* Reinforced Concrete Design by S.N. Sinha, Tata McGraw-Hill Publishing*:* 8. Limit State Design of Steel Structures by S.K. Duggal, McGraw Hill publications

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	1	-	-	2	-	2
CO3	-	2	3	-	-	-	-	2	-	2	2	2

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO852	**Reliability Engineering**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Engineering Mathematics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	· CO1: Apply the concepts of probability and statistics in reliability analysis. · CO2: Aanalyze data for finding failure probability. · CO3: Apply Monte carlo simulation technique in reliability analysis to solve different engineering problems. · CO4: Develop the concepts of statistical quality control and reliability tests.
Topics Covered (Hrs)	**Elements of probability and statistics**: Basictheory of probability, random variable, functions of random variables, multiple random variables, Joint PMF, PDF, CDF, Conditional probability, Probability distributions (discrete and continuous), basic statistics, covariance and correlation. (8) **Failures of Engineering systems**: Data analysis, Hazard models. (4) **Basic reliability analysis**: Introduction, Definition of reliability, Different

	classical reliability analysis methods: First Order Reliability Method, Second Order Reliability Method, Engineering applications. (10) **Simulation Techniques**: Monte Carlo simulation technique, theory and applications. (4) **Statistical Quality Control and Reliability Tests:** Statistical Quality Control, Statistical Reliability Tests, Accelerated Testing, Goodness of fit tests. (8) **System reliability**: Modeling, parallel and series system, Reliability improvement and allocation. (6)
Text Books, and/or reference material(s)	**Text Book(s)** 1. Probability concepts in engineering and design by Ang and Tang, John Wiley. 2. Probability, reliability and statistical methods in engineering design by A. Halder and S. Mahadevan, John Wiley and Sons. New York. 3. Probability, random variables and stochastic processes by A. Papoulis, McGraw Hill New York. ***Reference Book(s):*** 4. Practical Reliability Engineering by Patrick O'Connor, Andre Kleyner, John Wiley and Sons, New York.

Mapping of Course Outcomes Cos → POs

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

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHO851	**ENERGY, ENVIRONMENT & SUSTAINABILITY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
CHC401		CT+EA					
Course Outcomes	• CO1: Learn about energy technology of different conventional and non-conventional energy resource and Recent worldwide energy market scenario • CO2: Design & analyze of different renewable energy collectors and renewable energy thermal power plants • CO3: Learn industrial and domestic applications of different renewable energy sources • CO4: Solve energy technology problems of different difficulty levels through tutorials						
Topics Covered	**Module I:** Wind Energy: Sources and potentials, Wind energy conversion, General formula - Lift and Drag- Basis of wind energy conversion – Effect of density, frequency						

	variances, angle of attack, and wind speed. Windmill rotors Horizontal axis and vertical axis rotors. Determination of torque coefficient, horizontal and vertical axis windmills, performance characteristics, Betz criteria, Design and analysis of wind turbines. geographical aspects. [10 hrs.] **Module II:** Solar Energy: Energy available form Sun, Solar radiation data, Solar energy conversion into heat, Flat plate and Concentrating collectors, Construction and performance analysis of solar flat plate collectors, Mathematical analysis of Flat plate collectors and collector efficiency, collector efficiency factor, tilt factors, collector heat removal factor, Hottel-Willier-Bliss equation. Principle of Natural and Forced convection, Salt gradient solar ponds: construction, operation, technical problems, Solar drying and dehumidification: Solar cabinet dryers, convective dryers Solar engines-Stirling, Brayton engines, Photovoltaic, p-n junction, solar cells, PV systems, Stand-alone, Grid connected solar power satellite. [10 hrs.] **Module III:** Nuclear Energy: Nuclear fission principles, types of nuclear reactors (BWR, PWR, PHWR, LMCR, GCR, FFR). Nuclear reactor analysis: four factor formula, resonance absorption, reactor buckling, multiplication factor, thermal utilisation coefficient, reflector saving, fast fission factor, optimum moderator to fuel ratio. Radioactive waste disposal **Energy from Ocean:** Wave, Tidal and OTEC energy- Difference between tidal and wave power generation, Principles of tidal and wave power generation, OTEC power plants (closed cycle, open cycle, hybrid cycle), operation and technical problems, environmental impact, Tidal power, salinity power plants, **Geothermal systems:** Resources, types of wells, methods of harnessing the energy, Hot water and dry steam systems, energy extraction principles. [10 hrs.] **Module IV:** **Energy from biomass:** Biomass utilization: pyrolysis, gasification, anaerobic digestion (biogas production). Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, Biodiesels: Manufacture and characteristics. **Gasohol:** Characteristics and manufacture, use of pervaporation technology. Synthetic liquid fuels from coal: F – T Process, Coal hydrogenation, MTOG process. [10 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Ashok V Desai, Non-Conventional Energy, Wiley Eastern Ltd, New Delhi, 2003 2. K M, Non-Conventional Energy Systems, Wheeler Publishing Co. Ltd, New Delhi, 2003. Suggested Reference Books: 1. Ramesh R & Kumar K U, Renewable Energy Technologies, Narosa Publishing House, New Delhi, 2004 2. Wakil MM, Power Plant Technology, McGraw Hill Book Co, New Delhi, 2004. 3. G. D. Rai Non – Conventional Energy Sources. Khanna Publication 4. S P Sukhatme and J K Nayak, Solar Energy, McGraw Hill Book Co, New Delhi 4th Edition, 2017

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	3	2	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1
CO4	3	3	3	3	3	2	2	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="8">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSO 851</td><td>Machine Learning</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3">Basic concept of Probability and Statistics.</td><td colspan="5">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understanding of the basic concepts, fundamental issues and challenges of machine learning.
• CO2: Comprehend the principle and techniques of supervised learning.
• CO3: Explain the basic concepts and techniques of unsupervised learning.
• CO4: Understanding of the basic concepts and challenges of reinforced learning.
• CO5: Ability to apply the concepts of machine learning in different domains.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Introduction: what is Machine Learning; Human learning and Machine learning; Well-posed learning problem; Types of Machine Learning: Supervised, Unsupervised, and Reinforcement learning; Applications, Issues, and tools of Machine Learning. (03 L)
2. Concept Learning: Inductive learning hypothesis, general to specific ordering of hypothesis; FIND-S algorithm; Version space, candidate elimination algorithm; Inductive bias. (04 L)
3. Bayesian Learning, Naïve Bayes Classifier, Optimal Classifier. (03 L)
4. Supervised learning: Classification- k-Nearest Neighbour, Decision Tree, Support vector machine. Regression- Simple and Multiple linear regression. (12L)
5. Artificial Neural Networks: Biological neuron and artificial neuron, How ANN works, Parallel distributed model of ANN; Activation functions; Perceptron, McCulloch-Pits model, ADALINE network model; Architecture of ANN- single-layer feed forward, multi-layer feed forward, competitive network, recurrent network; Backpropagation algorithm; Basic concept of deep learning. (05L)
6. Unsupervised learning: Different clustering techniques- Partitioning methods (k-means, k-medoid, etc. clustering techniques), Hierarchical methods (Agglomerative and Divisive techniques: MIN, MAX, Group average, Ward's etc. methods), and Density-based method (DBSCAN). (05 L)
7. Unsupervised learning: Rule mining and Association analysis- different terminology (itemset, support count, support, association rule, confidence, etc.); Association rule mining techniques; Market-Basket analysis; Apriori principle, Apriori algorithm for frequent itemset generation, Rule generation for apriori algorithm. (05 L)
8. Genetic Algorithm based Learning. (02 L)
9. Reinforcement Learning: Basic concept, Model based learning, Temporal difference based learning. (03 L)</td></tr>
</table>

	10. Standards: Introduction to standardization efforts IS/ISO/IEC/22417 and 20546 (2L)
Text Books, and/or reference material	Text Books: 1. Machine Learning by Tom Mitchell [Mc. Graw-Hill]. 2. Machine Learning by S. Dutt, S. Chandramouli, and /A. K. Das [Pearson, 2019]. 3. Applied machine Learning by M. Gopal [Mc. Graw-Hill, 2018]. 4. NPTEL Course materials. **Reference Books:** Introduction to Machine Learning by Ethem Alpaydin [MIT Press].

Mapping of CO (Course Outcome) and PO (Programme Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 852	**Data Analytics**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					

Course Outcomes	• CO1: Classify the labelled dataset into different classes and group the unlabelled dataset into different clusters by uncovering hidden patterns and correlations among them.. • CO2: Model a problem into a graph database after absorbing and connecting a large volume of data and performing the analytical task over the graph. • CO3: Develop a recommendation system by predicting users' preferences based on similarity measures and evaluating its performance using the metrics such as Precision, recall, and F1-score. • CO4: Understand and set up the Hadoop framework, which will allow them to efficiently manage and process big data in a distributed computing environment.
Topics Covered	Introduction to Data Analytics, Types of Data Analytics: Descriptive Analytics, Diagnostic Analytics, Predictive Analytics, and Prescriptive Analytics. Use Cases, Issues and Challenges in Big Data Analytics. (4L) Fundamentals of Statistics: Population, Sample, Parameter, Statistic, Variable. Descriptive Statistics, Inferential Statistics. Basic Probability Theory: Random Experiment, Sample Space, Random Variables, Probability, Conditional Probability, Independence, Conditional Independence, Expectation, Variance, Probability Distribution, Joint Probability Distribution, Conditional Probability Distribution. (8L) Similarity Measures: Jaccard Similarity, Cosine Similarity, Adjusted Cosine Similarity. Missing Value Prediction Techniques: Mean Centering, Weighted

	Average, Z-Score. (6L) Basics of Complex Network: Scale-Free Networks, Small-World Phenomenon, Degree Distributions, Transitivity or Clustering. Centrality Measures: Degree Centrality, Betweenness Centrality, Closeness Centrality, Eigenvector Centrality, PageRank Centrality. Community Structure, Community Detection Algorithms: Girvan-Newman, Fast Greedy, Label Propagation, Clique Percolation Method. Community Quality Metrics: Modularity, NMI, Conductance. (10L) Introduction to Data Mining, Machine Learning Techniques: Least Square Regression, Decision-trees, SVM. Clustering Techniques: K-Means. (8L) Introduction to Hadoop Ecosystem – HDFS, Map-Reduce, PIG, HIVE, HBase, Mahout, Zookeeper, Flume, Sqoop, etc. (6L)
Text Books, and/or reference material	**Text Books:** 1. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data – EMC Education Services – Wiley. 2. Machine Learning: Hands-On for Developers and Technical Professionals – Jason Bell – Wiley. **Reference Books:** 1. Networks: An Introduction – M. E. J. Newman – Oxford University Press. 2. Hadoop: The Definitive Guide – Tom White – O'Reilly.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	1	-	-	-	2	-	1	-	-
CO2	3	3	3	3	-	1	2	-	2	2	3	
CO3	3	3	3	3	1	1	3	-	2	2	3	1
CO4	2	2	1	1	3	3	1	2	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO853	Distributed Computing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Operating Systems, Computer networks.		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		• CO1: To explain the paradigm of distributed computing. • CO2: To explore various existing and possible architectures of distributed systems. • CO3: To properly appreciate the issues that arise in distributed systems and explore solutions for the problems. • CO4: To fully appreciate the advantages to be obtained from a distributed environment wrt fault tolerance, load sharing etc.					

Topics Covered	Introduction to Distributed Systems. Motivations. Design Issues. (3L) Clocks in a Distributed System. Synchronization Issues. Logical Clocks. Causal relationships. Vector Clocks. (3L) Distributed State Detection. Global State. Consistent Cut. Global State recording algorithm. (2L) Termination Detection. Credit based algorithm. Diffusion Computation based algorithm. (2L) Distributed Mutual Exclusion. Token based and non-token based algorithms. (4L) Deadlocks in Distributed Systems. Resource allocation Models. Deadlock Prevention. Deadlock Avoidance – Safe states. Deadlock detection and Correction. Phantom Deadlocks. Centralized, Distributed and Hierarchical deadlock detection algorithms (5L) Fault recovery. Classes of Faults. Backward and Forward recovery. Log based recovery. Checkpoints. Shadow paging. (5L) Fault Tolerance. Data Replication. Quorum Algorithms . Distributed Commit Protocols. 2-phase commit. 3-phase commit. Election Algorithms. Bully algorithm. Ring topology algorithm. (8L) Byzantine faults and Agreement Protocols. (2L) Distributed File systems. Mechanisms. Stateful and Stateless servers. Scalability. Naming and Name Servers. (4L) Distributed Scheduling. Load Balancing. Load Estimation. Stability. Process Migration. Remote Procedure Calls. Transparency. Binding. (4L)
Text Books, and/or reference material	**Text Books:** Advanced Concepts in Operating Systems. Singhal and Sivaratri. McGraw Hill. **Reference Books:** 1. Operating Systems : A Concept Based Approach. Dhamdhere. McGraw Hill. 2. Distributed Operating Systems : Concepts and Design. P.K.Sinha. Prentice Hall. 3. Distributed Operating Systems. A.Tanenbaum. Pearson Education. 4. Distributed Systems : Concepts and Design. Coulouris et.al. Pearson Education.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	1	2	3	3	3	-
CO2	3	3	3	3	2	1	1	2	3	3	3	-
CO3	3	3	3	3	2	1	1	2	3	3	3	-
CO4	3	3	3	3	2	1	1	2	3	3	3	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 854	Game Theory and its Applications	PEL	3	0	0	3	3
MAC 01: Mathematics – I, MAC 02: Mathematics - II		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					

Course Outcomes	• CO1: Can have the efficiency to act in a strategic situation. • CO2: Can analyse the strategic interactions among agents. • CO3: Can understand modern state of the art in Game Theory. • CO4: Will have the knowledge of related area where Game Theory can be applied.
Topics Covered	**Introduction:** Motivation to the course. (2L) **Non-Coperative Game Theory:** Introduction to Game Theory, Extensive Form Games, Strategic Form Games, Dominat Strategy Equilibria, Pure Strategy Nash Equlibrium, Mixed Strategy Nash Equilibrium with examples. (8L) **Mechanism Design without Money**: One sided and two sided matching with strict preferences, Voting theory, and Participatory democracy. (5L) **Mechanism Design with Money:** Auction basics, sponsored search auctions, Revenue optimal auctions, VCG Mechanisms. Online auctions. (6L) **Cooperative Game Theory**: Coalitional Games, The Core, and The Shapley Value. (4L) **Repeated Games:** Introduction to repeated games and its Applications. (4L) **Applications:** Incentive Study in - P2P Networks, Crowdsourcing. (5L) **Some Special Topics**: Fair Division, Price of Anarchy, Scoring rules, Learning in Auction, Synergies between Machine Learning & Game Theory. (8L)
Text Books, and/or reference material	**Text Books:** 1. N. Nisan, T. Roughgarden, E. Tardos, and V. V. Vazirani. Algorithmic Game Theory. Cambridge University Press, New York, NY, USA, 2007, ISSN: 978-0521872829. 2. M. Maschler, E. Solan, and S. Zamir. Game Theory, Cambridge University Press; 1st Edition, ISSN: 978-1107005488, 2013. 3. Y. Narahari. Game Theory and Mechanism Design. World Scientific Publishing Company Pte. Limited, 2014, ISSN: 978-9814525046. 4. T. Roughgarden, Twenty Lectures on Algorithmic Game Theory, Cambridge University Press, 2016, ISSN: 978-1316624791. **Reference Books:** 1. T. Roughgarden, CS364A: Algorithmic Game Theory Course (Stanford University), 2013. 2. T. Roughgarden, CS269I: Incentives in Computer Science Course (Stanford University), 2016. 3. S. Barman and Y. Narahari, E1:254 Game Theory Course (IISc Bangalore), 2012.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	-	2	2	1	1	1	2	1
CO2	3	3	3	3	1	1	1	-	1	1	2	2
CO3	3	2	3	3	2	2	2	2	1	1	2	3
CO4	1	2	3	3	3	2	2	1	1	1	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="8">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSO 855</td><td>Information Security</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3">Programming Languages, Computer Networks and Operating Systems</td><td colspan="5">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Learn fundamental concepts of Information Security viz. Security Models (like the CIA triad), Access Control Mechanisms, Security policies and Security Mechanisms like authentication, identification, authorization, non-repudiation, etc.
• CO2: Understand program security issues, attack vectors, and malicious code including worms, viruses, and Trojan horse and logic bombs.
• CO3: Understand common vulnerabilities like Buffer Overflow, TOC-TOU flaws. Learn secure programming requirements; write robust security code and exploit/recreate-and-fix common vulnerabilities in software.
• CO4: Define trusted computing base and Operating System hardening as defence mechanisms, Intrusion detection and prevention.
• CO5: Get introduced to trusted computing and multilevel security.
• CO6: Explain concepts related to applied cryptography, including plain-text, cipher-text, four techniques for crypto-analysis, symmetric cryptography, asymmetric cryptography, digital signature, message authentication code, hash functions, and modes of encryption operations.
• CO7: Explain and compare security mechanisms for conventional operating systems, OS hardening. Case Study on Linux.
• CO8: Exposed to network and distributed systems security issues and solutions including authentication, key distribution and management and network security protocols like SSL/TLS.
• CO9: Introduced to Laws and regulatory requirements, security standards and controls, risk management, security metrics and performance indicators, security auditing, education, training and awareness and digital forensics.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">▪ Information Security Introduction -- Defining and Understanding security through security models, Confidentiality, Integrity and Availability, formal description of security, Attacks and Defences, Threats, Vulnerabilities and Risk, Assurance, Prevention, Detection, Security Controls. [2L]
▪ Identification and Authentication. [2L]
▪ Authorization and Access Control, Access Control Models & Mechanisms and Multilevel Security. [2L]
▪ Auditing and Accountability. [2L]
▪ Computational Number Theory & Cryptography -- Fermat's theorem, Euler's theorem, Euclid's algorithm, manually and computationally encrypt/decrypt, sign/verify signatures for small messages using RSA, Deffie-Hellman and DSA algorithms.
Applied cryptography viz. Symmetric key Cryptography, asymmetric Cryptography and Digital Signatures, message authentication codes, hash functions and modes of cryptographic operations.[6L]
▪ Physical Security. [1L]</td></tr>
</table>

	▪ Network Security – Network threats: eavesdropping, spoofing, modification, denial of service attacks o Introduction to network security techniques: firewalls, virtual private networks, intrusion detection. Different Network Security Protocols.[6L] ▪ Operating System Security & Trusted OS-- Memory, time, file, object protection requirements and techniques, Protection in contemporary operating systems, ACLs, DAC, MAC, RBAC, Identification and authentication, Identification goals, Authentication requirements, Human authentication, Machine authentication, OS Forensics. Assurance & Trust, Design principles, Evaluation criteria, Evaluation process.[8L] ▪ Application & Program Security– Flaws, Malicious code: viruses, Trojan horses, worms, Program flaws: buffer overflows, time-of-check to time-of-use flaws, incomplete mediation o Defenses, Software development controls, Testing techniques.[5L] ▪ Secure Coding. [2L] ▪ Distributed Systems Security. [2L] ▪ Digital Forensics. [2L] ▪ Cyber Laws. [2L]
Text Books, and/or reference material	**Text Books:** 1. The Basics of Information Security by Jason Andress, Syngress Publication. 2. Security in Computing (3rd Edition) 3rd Edition by Charles P. Pfleeger (Author), Shari Lawrence Pfleeger (Author), PHI. 3. B. Tjaden Fundamentals of Secure Computer Systems Franklin Beedle & Associates 2003. 4. D. Russell & G.T. Gangemi, Sr, Computer Security Basics. 5. W. Stallings, Network Security Essentials. Prentice Hall, 2003.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	-	-	1	-	-	-	1
CO2	1	-	3	-	3	-	-	-	-	-	-	-
CO3	2	2	2	2	3	-	-	-	-	-	3	-
CO4	-	2	2	2	3	2	-	1	-	-	-	1
CO5	-	-	-	-	3	3	-	-	-	-	2	1
CO6	2	2	2	2	2	-	-	-	-	-	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 856	Optical Network	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Basic Concepts of Computer Networks		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		• CO1: Learn the fundamental concepts of optical networks. • CO2: Understanding the basic concepts and solution techniques for the different fundamental problems like routing and wavelength assignment					

	(RWA), virtual topology design, wavelength rerouting, and traffic grooming in optical network design. • CO3: Acquire knowledge of the wavelength convertible network. • CO4: Comprehend the basic concepts of multicast routing in optical networks.
Topics Covered	1. **Fundamentals and Optical Components**: Optical fiber principles, Optical transmission system, Wavelength Division Multiplexing(WDM), optical networking evolution, Optical Network Architectures; Optical Components- Couplers, Multiplexers and Filters, Optical Amplifiers, Transmitter, Detectors, switches and wavelength converters; Different issues in wavelength routed networks. (12L) 2. **Routing and Wavelength Assignment (RWA) algorithms**: ILP formulation of the RWA problem, Route Selection algorithms – Fixed Routing, Fixed Alternate Routing, Exhaust Routing, Least Congested Path Routing, Limited alternate Routing. Wavelength Selection algorithms. Joint wavelength-Route selection algorithm. (08L) 3. **Wavelength Convertible Networks**: Need for Wavelength Converters, Wavelength convertible Switch Architecture, Routing in Convertible Networks, Performance Evaluation of Convertible networks, Network with Sparse Wavelength Conversion, Converter Placement problem. (04L) 4. **Wavelength Rerouting Algorithm**: Benefits of wavelength rerouting, Issues in wavelength rerouting, Different rerouting algorithms. (05L) 5. **Virtual Topology Design**: Concept of virtual topology, Limitations on virtual topology, Virtual topology problem formulation, Virtual topology design algorithms. (06L) 6. **Traffic Grooming:** Basic concepts, Grooming node architecture, ILP formulation of the traffic grooming problem, Different heuristics (MST, MRU, TGCP, etc) for the traffic grooming problem. (05L) 7. **Basic concepts of** Multicast routing and wavelength assignment. (02L)
Text Books, and/or reference material	**Text Books:** 1. WDM OPTICAL NETWORKS Concepts, Design and algorithm by C. Siva Ram Murthy and Mohan Gurusamy (PHI). 2. OPTICAL NETWORKS by Biswanath Mukherjee (TMH). **Reference Books:** 1. Optical Networks: A Practical Perspective (3rd Edition) by R. Ramaswami, K. Sivarajan, G. Sasaki (Morgan Kaufmann Publishers).

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	1	1	-	-	-	-	-	-	2
CO2	2	3	3	3	2	-	-	-	-	-	-	3
CO3	2	3	3	2	2	-	-	-	-	-	-	3
CO4	2	3	2	2	1	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Electronics and Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO850</td><td>Communication Network</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods
(Continuous (CT), Mid-Term (MT) and End Assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Identify communication networks suitable for different operational scenarios.
• CO2: Install and troubleshoot typical communication networks.
• CO3: Explain the information flow through various subsystems of a network.
• CO4: Realize the integration between various subsystems of a network.
• CO5: Interpret the current communication technology trends.
• CO6: Evaluate the business potential of future communication networking paradigms.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Elements of communication network [2 hrs.]
Network – nodes, links, advantages, evolution path.
Switching – circuit switching, packet switching, store and forward mechanism.
Module 2: Computer networks [8 hrs.]
Computer networks – Ethernet, topology, Ethernet address and IP address.
Interconnecting Ethernets – Hub, Switch, Router.
Layered architectures – Netwrok protocols, TCP/IP, OSI.
Module 3: Landline telephone networks [8 hrs.]
Fundamentals – elements (end nodes, transmission media, switching, signaling), design parameters (GoS, blocking probability, time and call congestion), centralized and distributed switching.
Telephone system – handset, CBS, base unit, transmission impairments, subscriber loop design.
Module 4: Cellular mobile networks [8 hrs.]
Cellular networks – cellular concept, PCS standards (GSM, CDMA), PCS architecture, How a call comes to your mobile phone?
WiFi and Bluetooth.
Module 5: Optical networks [8 hrs.]
FDDI – topology and architecture, access and priority mechanisms, applications.
SONET – topology and architecture, frame format, equipments, deployment and applications.
Under Sea networks – global architecture, how India is served by them?
Module 6: Satellite networks [8 hrs.]
Fundamentals – types of satellites, frequency bands, basic satellite components.
VSAT networks – architecture and applications.
Mobile satellite networks – Iridium, Globalstar.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Book:
1. Communication Networks - J. Walrand.
Reference Books:
1. Telecommunication Switching and Networks - P. Gnanasivam.
2. Optical and Wireless Communications – M. N.O. Sadiku.</td></tr>
</table>

COURSE ARTICULATION MATRIX

PO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	2	1	2	1	2	1	1	1	1	1	1
CO#2	3	3	3	1	2	1	1	1	2	1	1	1
CO#3	3	2	3	1	1	1	1	1	1	1	1	1
CO#4	2	2	3	3	2	2	2	1	1	1	1	1
CO#5	1	1	2	2	1	3	2	1	1	2	2	1
CO#6	1	1	2	3	1	3	3	2	1	2	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Electronics and Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO851</td><td>Mobile Computing</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3">Data Communication and Computer Networks (ECE618)</td><td colspan="5">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Introduce to the basic of Wireless Networks.
• CO2: Preparing the right background to take up research works in emerging wireless technologies and Internet of Things.
• CO3: To introduce the scopes of using sensing, edge computing, Machine learning mechanisms in pervasive cyber physical systems.
• CO4: Able to understand the innovation opportunity in IoT application segments.
• CO5: Hands-on experience on Wireless Networks & Mobile Computing.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Physical Layer (6 Hours)
Bit transmission over Wireless, Vary Much different from Wired Network.
Module 2: Mac Layer (8 Hours)
Access in Shared Medium, Difference between Wired MAC & Wireless MAC, Different Type of MACs (a) Random MAC (b) Scheduled MAC, Examples of MAC Implementation (WiFi Protocol --802.11, Bluetooth Protocol--805.15).
Module 3: Network Layer (8 Hours)
Reactive Routing, Proactive Routing, DSR Principle, AODV Principle, Location Aware Routing. Adhoc Network, Delay Tolerant Network, Opportunistic Network Introduction, Architecture & Applications, Routing Algorithms – Epidemic, Prophet, Spray & Wait, Spray & Focus, Maxprop Simulation Tool - ONE Simulator.
Module 4: Transport Layer (8 Hours)
Wireless TCP and rationale, Difference between Wired TCP and Wireless TCP, QoS Measurement of Wireless Networks.
Module 5: Modelling (8 Hours)
Mathematical Modelling of Network Functionalities - Combining them to derived overall performance.
Module 6: Case Study: Implementation of opportunistic Networks in</td></tr>
</table>

	Challenged Network scenarios **(4 hours)** (a) Connection Mechanism (b) Sync - Transferring the information in Collaborative manner (c) Offline Dashboard (Information Summarization) (d)security
Text Books, and/or reference material	**Text Books:** 1. "Mobile Communication", by Jochen Schiller (PEARSON EDUCATION LIMITED). 2. "Wireless Networking" A kumar, D. manjunath, J. Kuri, Elsevier, 2008. 3. "Wireless Communication", T. S. Rappaport, Pearson, latest edition. **Research Papers:** 1. IEEE Infocom Tutorials slides by Prof. Nitin Vaidya. **Others:** Tools: • Sniffer Tool (Wireshark) • Simulation Tools: OMNET, ONE, NS3

COURSE ARTICULATION MATRIX

PO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	3	2	1	1	1	1	1	-	2	-	2
CO#2	3	2	2	2	2	1	1	-	-	1	1	2
CO#3	3	2	3	3	3	2	2	1	-	3	3	2
CO#4	3	3	2	1	1	1	1	1	-	2	-	2
CO#5	3	2	2	2	2	1	1	-	-	1	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO852	MEMS Technology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and End Assessment (EA))					
Basic Electronics (ECC01), Engineering Mechanics (XEC01)		Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination					
Course Outcomes	After the completion of the course the student will be able to • **CO 1**: Understand characteristics of MEMS system • **CO 2**: Understand fundamental building blocks of general MEMS systems • **CO 3**: Apply qualitative and quantitative analysis techniques in general MEMS systems • **CO 4**: Understand fabrication technology of MEMS system • **CO 5**: Investigate application specific MEMS systems						

Topics Covered	**Module I: Introduction to MEMS & Microsystems Technology [L-1]** History of MEMS technology, Commercial MEMS devices, Application of MEMS devices **Module II: Electromechanical transduction techniques [L-5]** Electrostatic transduction, Electromagnetic transduction, Piezoelectric transduction, Piezoresistive transduction **Module III: Characteristics of MEMS Devices [L-6]** Static characteristics, linearity, nonlinearity, Sensitivity, Resolution, Hysteresis, Dynamic characteristics, Response time, Delay time, Gain, Bandwidth, Quasi static characteristics of MEMS devices. **Module IV: Analysis and Modelling of MEMS devices [L-6]** Concept of Energy, Co-energy, Energy methods, Lagrange equations, Physics based model, Lumped model, Finite element model **Module V: Effect of noise [L-2]** Sources of different types of noise, Thermal noise, Environmental noise, Noise modelling techniques, Statistical methods of noise modelling **Module VI: Integration and packaging [L-6]** Transducers in MEMS, MEMS sensors, MEMS actuators, Integration of MEMS transducers with signal conditioning /driver circuits, Signal amplifiers, Signal filters **Module VII: MEMS device fabrication processes [L-10]** MEMS materials, Bulk micromachining, Silicon anisotropic etching, Surface micromachining, **Module VIII: Scaling effect, Reliability of MEMS devices [L-2]** Effect of inertia in MEMS devices, Scaling effect of MEMS devices, Concept of reliability, Mathematical modelling of reliability, Reliability analysis of MEMS devices. **Module IX: Case studies in MEMS [L-4]** Application specific MEMS devices, MEMS blood pressure sensors, MEMS microphone, MEMS accelerometer, MEMS gyro
Text Books, and/or reference material	**Text Books:** 1. S. D. Senturia, *Microsystem Design*, Springer; 1st edition, 2004 2. K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat, V.K. Aatre, G.K. Ananthasuresh, *Micro and Smart Systems*, Wiley India Pvt Ltd, 2010 **Reference books:** 1. Research Articles

COURSE ARTICULATION MATRIX

PO / CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	-	-	-	-	-	-	-	-	-	-	-
CO#2	2	3	-	-	-	-	-	-	-	-	-	-
CO#3	3	2	-	-	-	-	-	-	-	-	-	-
CO#4	3	2	-	-	-	-	-	-	-	-	-	-
CO#5	3	1	-	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Electronics and Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO853</td><td>Electronic System Design</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA)):</td></tr>
<tr><td colspan="3">Basic Electronics (ECC01)
Engineering Mechanics (XEC01)</td><td colspan="5">Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After the completion of the course the student will be able to
• CO 1: Understand concept of electronic systems
• CO 2: Understand basic building blocks of electronic systems
• CO 3: Apply quantitative analysis techniques to electronic systems
• CO 4: Learn design techniques of electronic measurement systems
• CO 5: Investigate application specific measurement systems</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I: Introduction to electronic systems [L-1]
Module II: Static and dynamic characteristics [L-6]
Static characteristics of elements, Dynamic characteristics of elements, Quasi-static characteristics of elements, Static characteristics of systems, Dynamic characteristics of systems, linearity, non-linearity, Sensitivity, Resolution, Repeatability, Reproducibility, Response time, Settling time, Gain, bandwidth.
Module III: Electro-Multiphysics Actuation Systems [L-7]
Electro-magnetic actuators, Electro-mechanical actuators, Electro-thermal actuators,
Electro-chemical actuators, Electro-optic actuators, Additional Multiphysics Mechanisms, Electro-Multiphysics drivers.
Module IV: Microcontrollers, Microcomputers and signal processing unit [L-5]
8051, Arduino, Raspberry pi
Module V: Sensors [L-8]
Temperature sensors, Force sensors, Pressure sensors, Vibration sensors, Flow sensors, Motion Sensors, Magnetic flux sensors, Chemical sensors.
Module VI: Signal Conditioning circuits [L-6]
Bridge circuits, Amplifiers, Filters, Oscillators, ADC
Module VII: Data presentation unit [L-3]
Several data presentation devices
Module VIII: Electronic controllers [L-4]
Open loop systems, Closed loop systems, PID controllers
Module IX: Case studies [L-2]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
4. J. Bentley, Principles of measurement systems. Pearson Education India; 3rd edition, 2002
5. W. Bolton, Mechatronics, Fourth Edition, Pearson, 2010
6. Ernest O. Doebelin, Dhanesh N. Manik, Doebelin's Measurement Systems: 7th Edition McGraw-Hill; Seventh edition, 2019
7. David A. Bell, Electronic Instrumentation and Measurements, Oxford University Press India; Third edition, 2013
Reference books:
1. Research Articles</td></tr>
</table>

COURSE ARTICULATION MATRIX

PO / CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	-	-	-	-	2	-	-	-	-	-	-
CO#2	2	3	-	-	-	-	-	-	-	-	-	-
CO#3	1	3	-	-	-	-	-	-	-	-	-	-
CO#4	2	1	2	-	-	2	-	-	-	-	-	-
CO#5	1	1	1	3	-	2	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEO850</td><td>SOFT COMPUTING TECHNIQUE</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEE 610(NUMERICAL ANALYSIS)</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: For a given non-linear or non-derivative problem, tune the control parameters of adaptive particle swarm optimization (APSO) for efficiently controlling the global exploration and local exploitation.
• CO2. Analyze the genetic algorithms, PSO, DE and their applications
• CO3: For a given single objective problem (SOP), apply binary coded genetic algorithm (BCGA) and real coded genetic algorithm (RCGA) with different types of crossovers, mutation and also understand the impact of different parent selection strategies.
• CO4: For a given multi-objective problem, explain the significance of Difference vector in Differential Evolutionary (DE) technique and also illustrate self-adaptive differential evolutionary (SADE) technique.
• CO5: For a given problem, describe fuzzy knowledge base controller (FKBC) showing information and computational flow with membership function, rule base and defuzzification.
• CO6: For a given problem, logically clarify the impact of hidden layers in artificial neuron network (ANN) and also stepwise explicate the back propagation algorithm of ANN.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Hard Computing and Soft-Computing techniques, Conventional & non-conventional approaches, limitations of hard computing techniques, merits & demerits of soft-computing techniques, practical examples associated with soft-computing techniques. (3)
Fundamental concept of optimization techniques and necessity of optimization techniques, types of optimization techniques, coding, fitness/objective function, algorithms. (2)
Introduction of Particle Swarm Optimization (PSO) algorithm, Bird flocking & fish schooling, velocity, inertia weight factor, pbest solution, gbest solution, local optima, global optima, Flowchart/algorithm, examples, new modifications of PSO, Parameter Selection in PSO. (6)
Introduction of genetic algorithm, Binary coding & decoding, Genetic modelling, Reproduction, Crossover, Mutation, importance of crossover and mutation</td></tr>
</table>

	operators, parent selection strategy, parent selection methods, Flowchart/algorithm, drawback of binary coded genetic algorithm (BCGA), real coded genetic algorithm (RCGA), examples. (6) Fundamentals of Differential Evolution algorithm, difference vector and its significance, Mutation and crossover, comparisons among DE, PSO and GA, Examples, new modifications of DE, Improved DE schemes for noisy optimization problems. (6) Biological neural networks, Model of an artificial neuron, neural network architecture, Characteristics of neural network, learning methods, Taxonomy of neural network architecture, Back propagation networks, architecture of a back propagation network, back propagation learning, Examples, RBF network, Associative memory, Adaptive resonance theory. (7) Fuzzy set theory, Fuzzy systems, crisp sets and fuzzy sets, fuzzy set operations and approximate reasoning, Fuzzification, inferencing and defuzzification, Fuzzy knowledge and rule bases, examples. (6) Applications of Soft Computing to various fields of engineering. (6)
Text Books, and/or reference material	Text Books: 1. Devendra K. Chaturvedi, "Soft Computing- techniques and its application in electrical engineering", Springer, 2008. 2. Carlos A. Coello,Garry B. Lamont, David A. van Veldhuizen, "Evolutionary Algorithms for solving Multi-objective Problems", Second Edition, Springer, 2007. Reference Books: 1. Jyh-Shing Roger Jang, Chuen-Tsai Sun &EijiMizutani, Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, Prentice Hall 2. S. Rajasekaran and G. A. VijayalakshmiPai, Neural Networks, Fuzzy Logic and genetic Algorithm Synthesis and Applications, PHI 3. L. A. Zadeh, Fuzzy Sets and Applications, John Wiley & Sons

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	1	1	1	2	2	2	1
CO2	3	3	3	2	3	1	1	1	2	2	2	1
CO3	3	2	2	1	2	1	1	1	2	3	2	1
CO4	3	2	2	1	2	1	1	1	2	3	2	1
CO5	3	2	2	1	2	1	1	1	2	3	2	1
CO6	3	2	2	2	2	1	1	2	2	3	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO851	EMBEDDED SYSTEMS AND APPLICATION	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEC403 (DIGITAL ELECTRONICS)		CT+MT+EA					

Course Outcomes	• CO1: Demonstrate programming proficiency using the various addressing modes and data transfer instructions of the target microprocessor microcontroller. • CO2: Identify—and exercise—opportunities for hardware and software trade-offs. • CO3: Design of interfacing circuits such as memory, keyboard, display, ADC, DAC, DMA etc. and programming in assembly language for typical microprocessor-based system. • CO4: Given peripheral devices such as memory, ADC, DIOs, etc., design of interfacing circuit, and writing algorithms to fulfil a given specific application. • CO5: Programming processor specific and processor independent software for different complex embedded system applications.
Topics Covered	Introduction to Embedded systems: Introduction – Features – Microprocessors – ALU - Von Neumann and Harvard Architecture, Classification, SPP, ASIC, ASIP, CISC and RISC - Instruction pipelining. General characteristics of embedded system, introduction to different components etc. (3) Basic Microprocessor architectures, organizations and Instruction sets. (4) Memory Classification: ROM, EPROM, EEPROM, RAM. (4) Various types of Interrupts. (2) Programmable Peripheral Devices and Interfacing 8255, 8259, 8257, 8251, 8253, ADC, DAC and Practical Applications. (4) Microcontroller 89CX51/52 Series: Characteristics and Features, Overview of Architectures, and Peripherals, Timers, Counters, Serial communication, Digital I/O Ports. (3) Microcontroller PIC Series: Characteristics and Features, Overview of architectures, and Peripherals, Interrupts, Timers, watch-dog timer, I/O port Expansion, analog-to-digital converter, UART, I2C and SPI Bus for Peripheral Chips, Accessories and special features. (4) ARM Architecture: Evolution, Characteristics and Features, Overview of architectures, Modes, Registers etc. (6) Software architecture and RTOS: Software Architecture: Round Robin- Round Robin with interrupts -Function Queue. Scheduling Architecture RTOS: Architecture -Tasks and Task States -Tasks and Data -Semaphores and Shared Data Message Queues -Mail Boxes and pipes -Timer Functions -Events -Memory Management, Interrupt Routines. (6) Applications of Embedded systems in different field of engineering. (6)
Text Books, and/or reference material	Text Books: 1. The 8085 Microprocessor: Author: Ramesh Gaonkar, Pub: PRI 2. The 8051 Microcontroller and Embedded System: Author: Muhammad Ali Mazidi & J. G. Mazidi. 3. Advanced Microprocessors and Interfacing: Author: Badri Ram, Tata McGraw-Hill Publishing Co. Ltd. Embedded Systems Architecture, Programming and Design, Ral Kamal TMH, 2008. Reference Books: 1. Embedded Systems Design, Heath Steve, Second Edition-2003, Newnes, 2. Computers as Components; Principles of Embedded Computing System Design, Wayne Wolf Harcourt India, Morgan Kaufman Publishers, First Indian Reprint. 2001. 3. Embedded Systems Design – A unified Hardware /Software Introduction, Frank Vahid and Tony Givargis, John Wiley, 2002.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1		2	1	3	1	1	1	

CO2	3	1	2	1	1			1				1
CO3	3	3	3	3	3	1	1	1	1	1	1	1
CO4	3	3	3	3	3	1	1	1	1	1	1	1
CO5	3	3	3	1								1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="7">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEO852</td><td>MICRO-ELECTROMECHANICAL SYSTEM</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• CO1: Understanding the fundamentals of MEMS technology and its applications
• CO2: To study and learn the different aspects of Microfabrication Procedures.
• CO3: To learn about the Microfabrication Procedures.
• CO4: To study about the Microsensors and Micro actuators and their application.
• CO5: Learn about the RF-MEMS and Bio-MEMS techniques and applications.
• CO6: To learn the modelling and computer simulation techniques for MEMS designs.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Introduction to MEMS: Introduction to MEMS technology, Why MEMS, Advantages, Applications, examples of MEMS devices, MEMS in Electronic Industries, VLSI Technology for fabrication of integrated circuits chips. (3)
Fundamentals of Microfabrication Procedures: Introduction to Thin Film Technology, Clean rooms, Surface Micromachining, MEMS fabrications process flow (Deposition, Lithography and Etching), MEMS fabrication instruments, MEMS fabrication bench, Micromachining, Surface Modelling. (3)
Thin Film Deposition Techniques: Substrate Materials, Silicon Wafer, Metal Polymer, Plastic substrate, Thin Film Deposition Process, Physical Deposition process, Chemical Vapour Deposition, Sputtering, Electrodeposition, Electroplating, and Oxidation. (5).
Fundamentals of Lithography: Introduction to Thin Film Technology, Different Lithography Technique, Mask and Mask Material, Photoresists, Positive Photoresists, Negative Photoresists, Lift-off, LIGA. (5)
Etching Procedures: Need for etching process, different etching techniques, wet etching, dry etching, etching materials, Chemical Etching, Plasma Etching, precautions. (5)
Micro sensors and Micro actuators: Accelerometers, Gyroscopes, Angle-Sensors, Pressure Sensor, Microphones and MEMS sensors. (3)
Introduction to BioMEMS: MEMS technology in biomedical applications, Microelectrodes for Biomedical Engineering, Introduction to Microfluidics and its Applications. (4)
RF MEMS: MEMS for telecommunications (RF MEMS), RF MEMS Components, RFMEMS applications, Recent RF MEMS development, RF</td></tr>
</table>

	MEMS Limitations, RF MEMS Challenges. (3) Computational Modeling of MEMS and MEMS Devices: Overview of MEMS-CAD software; followed by tour of MEMS Design Centre, COMSOL, IntelliSuite. (4) Recent Development in Micro technology: Introduction to Nanotechnology, Carbon Nanotube, Graphene, CNT Sensors Graphene Sensors. (3)
Text Books, and/or reference material	Text Books: 1. An Introduction to Microelectromechanical Systems Engineering: Nadim Maluf, Artech House, 2000 2. Microsystem Technology: Wolfgang Menz, Jürgen Mohr, Oliver Paul, John Wiley & Sons, 2008. Reference Books: 1. An Introduction to Microelectromechanical Systems Engineering: Nadim Maluf, Kirt Williams, Artech House, 2004. 2. Fundamentals of Microfabrication: The Science of Miniaturization, Marc J. Madou, CRC Press; 2nd Ed. 2002. 3. MEMS: A Practical Guide to Design, Analysis, and Applications: Jan Korvink Oliver Paul, William Andrew; 1 edition (November 14, 2005

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	1	1	1	1	1	1	1
CO2	3	3	3	3	3	1	2	2	2	1	2	1
CO3	3	3	3	3	3	1	2	2	2	1	2	1
CO4	3	3	3	3	3	2	2	2	2	1	2	2
CO5	3	3	3	2	3	1	2	2	2	1	2	2
CO6	2	2	3	2	3	1	1	1	3	0	3	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEO 851	**Tribology**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NA		CT+EA					
Course Outcomes	CO1: To learn the basic knowledge of surface topography and contact between engineering surfaces. CO2: To learn the basic theory and application of friction and wear for different materials CO3: To learn about lubricants and lubrication for different bearings CO4: Introduced to Bio-tribology of human joints CO5: Introduced to Micro-tribology for MEMS applications						
Topics Covered	**Part I - Basic Tribology** **Surface topography:** Measurement of surface topography; Quantifying surface roughness; The topography of engineering surfaces. 2 **Contact between surfaces:** Hertzian contact – sphere on sphere contact and cylinder on cylinder contact; Contact between rough surfaces.						

	4 **Friction and Wear of contact surfaces:** Laws and Theories of friction and wear; Friction and Wear of different materials; Application to friction materials. 8 **Lubricants and lubrication:** Viscosity of lubricants; Composition and properties of oils and greases; Reynolds equation; Type of lubrications - Hydrostatic lubrication, Hydrodynamic lubrication; Elastohydrodynamic lubrication; Boundary lubrication, and application to bearings. 14 **Part II - Advanced Tribology** **Microtribology:** Surface forces and adhesion; Atomic force microscopy (AFM); Friction, wear and lubrication on atomic level; Applications to MEMS. 6 **Biotribology:** Natural human joints; Structure and properties of articular cartilage; Mechanism of synovial lubrication: Mechanism of articular cartilage damage; Artificial joint replacements; Skin Tribology 8)
Text Books, and/or reference material	**Text Books:** 1. Engineering Tribology - Dr. Prasanta Sahoo 2. Introduction to Tribology of Bearings-- B.C.Majumder 3. Principles of Tribology-- J.Halling 4. Basic Lubrication Theory - Alastair Cameron

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XEO851	Leadership and Corporate Strategy	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
nil		CT+MT+EA					
Course Outcomes	• CO1: Understanding the nature of leadership within human Behaviou • CO2: Understanding ethics and human values • CO3: Understanding the correlation of work –rewards- stress.						
Topics Covered	Introduction: The nature of Leadership; the nature of Managerial work, Effective Leadership Behaviour; Participative Leadership [4] Dyadic Role Making; Power and Influence; Managerial Traits and Skills [4] Charismatic and Transformational Leadership [2] Leadership in terms and Decision groups; Strategic Leadership by Executives [3] Developing Leadership Skills; Ethical Leadership and Diversity [2] Issues about research methods in leadership [1] Entrepreneurship: Introduction; Advantages of entrepreneurship; TE Analysis; Pitfalls of Entrepreneurship, difference between a entrepreneur and leader; qualities of an entrepreneur [4] Strategic Management Process: Vision, Mission, SWOT Analysis; Defining goals and objectives; key success factors for management. [6] Pricing Policy; Process of budget [2] Advertisement: Role and methods, the seven tests and pricing [1] Marketing: 4 P's of marketing Mix; Balance Scorecard [2].						

Text Books, and/or reference material	Suggested Text Books: 1. GARY YUKL. Leadership in Organizations ; Pearson Education, 2008 2. Thomas .W Zimmereer and Norman M. Scarborough. Essentials of Entrepreneurship and Small Business Management; Pearson Education; 2007. Suggested Reference Books: 1. Debasis Chatterjee; "Light the fire in your Heart "; Full Circle Pub. House.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	3	3	3	1	1	1	1	1	1	1	1
CO2	-	3	3	3	1	1	1	1	1	1	1	1
CO3	-	3	3	3	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

NEWLY INCLUDED SUBJECTS

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR)/ Elective (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO443	Digital Computer Design	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Basic Electronics		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		• CO1: Design the hardware building blocks of a computer system. • CO2: Analyze the various parts of modern computer functional units, bus structure, addressing modes and computer arithmetic. • CO3: Identify the process involved in executing an instruction and fetching the word from memory. • CO4: Design the hardwired and micro-programmed control units and implementation of interrupts. • CO5: Understand the memory hierarchy and design a memory system.					
Topics Covered		**UNIT-I**: **Digital logic circuits**: Digital Systems, Binary Logic and Basic Gates, Boolean Algebra, Logic Simplification using K-Map, Combinational Logic Circuits : Binary Adder, Subtractor, Magnitude Comparator, Decoder, Multiplexer; Sequential logic circuits : Flip-flop, register, shift register, Ring counter. (12L) **UNIT-II**: **Introduction to Computer Organization**: Evolution of computers, Basic Structure of Computers: Basic Operational Concepts, GPR based organization. Bus Structures, Machine Instructions and Programs: Memory Location and Addresses, Memory Operations, Instructions and Instruction Sequencing, Addressing Modes (10L) **UNIT-III**: **Processing Unit**: Combinational and Sequential ALU, ALU expansion strategies, Floating Point Numbers (IEEE754), Floating Point Operations. Fetching and Storing words, Register Transfer, Execution of instruction, timing & control, instruction cycle, Hard-wired Control, Micro programmed Control: Micro instruction, Microprogram sequencing (10L) **UNIT-IV: Input/output Organization**: Accessing I/O Devices, Interrupt.(4L) **UNIT-V**: **Memory System**: Basic Concepts, Semiconductor RAM Memories, Read Only Memories, Speed, Size, and Cost, Cache Memories – Mapping Functions, Replacement Algorithms, Virtual Memories, Secondary Storage. (6L)					

Text Books, and/or reference material	**Text Books:** 1. M. Morris Mano: "Digital logic and Computer Design" Pearson. 2. M. Morris Mano: "Computer System Architechture", Pearson. 3. Carl Hamacher, Zvonko Vranesic, Safwat Zaky: Computer Organization, Tata McGraw Hill. **Reference Books:** **1.** William Stallings, "Computer Organization and Architecture". 2. Nicholas P Carter, "Computer Architecture & Organisation".

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	1	-	-	-	-	-	-	1
CO2	3	1	2	2	1	-	-	-	-	-	-	1
CO3	3	1	3	3	1	-	-	-	2	-	-	-
CO4	3	2	3	3	2	-	-	-	1	-	-	-
CO5	3	2	3	3	2	-	-	-	1	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Management Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MSO441	**Essentials of Marketing Management**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Understand the evolution of marketing management • CO2: Analyse the marketing environment • CO3: Formulate marketing strategy for different products and services						
Topics Covered	• Understand markets and marketing management process: Creating Customer value and engagement. • Understanding the marketplace and consumer value: Analysing the internal marketing environment, examine challenges/opportunities arising from external competitive dynamics • Analyse factors that influence buyer's behaviour in the context of marketing decisions: Consumer markets and buyer behaviour, business markets and business buyer behaviour. • Customer driven marketing strategy: Examine the STP framework. Analyse various bases of segmentation. Formulate targeting and positioning strategies • Managing marketing information to gain customer insight: Identify the role of marketing research in the formulation and solution of marketing problems • Creating value for target customer: Understand how to build and manage product mix and product lines, analyse major marketing decisions involved in the management of product and service mix. • Building customer value: Determine the process of building strong brands and managing them, brand equity and its components • Understanding and capturing customer value: Understand the pricing process, factors determining the price, formulate pricing strategies for various products and services • Delivering customer value: Understand the importance of marketing						

	channel, analyse the distribution networks of various products, design distribution strategies for various categories of products and services • Communicating customer value: Understand and analyse the working of marketing communications, formulate integrated marketing communication strategies, advertising and public relations, personal selling and sales promotion, digital marketing.
	Text Book: 1. Marketing management: A south Asian perspective, Philip Kotler, Pearson Education India, 13th Edition, 2021 Reference Books: 1. Marketing 5e, Dhurv Grewal and Michael Levy, McGraw Hill Edu, 2017

CO-PO mapping matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO#1											2	3
CO#2				1					2		2	3
CO#3						2			2		2	3

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEO441	**Energy Management and Auditing**	**PEL**	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
-		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	**CO1:** To acquire the knowledge about energy conservation. **CO2:** Knowledge of energy conversion efficiency. **CO3:** Ability to evaluate the performance of pumps, fans, blowers, and industrial boilers etc. **CO4:** To gain knowledge about the energy conservation opportunities in various industrial processes. **CO5:** Students will be able to become energy manager and energy auditor in different industries.						
Topics Covered	**Introduction:** Importance of energy management, Role, Responsibilities and Duties of Energy manager and Energy Auditor, Energy Conservation Act and Calculation of energy consumption, Fundamental calculation in Mechanical, Thermal & Electrical system, Thermal energy basis, Measurement and instruments used in energy audit, Performance parameters for energy audit, Bureau of Energy Efficiency (BEE), Plant Energy Performance (PEP). **(10)** Material and Energy Balance, Energy analysis, Sankey diagram, Financial Management and analysis techniques, Project Management, Time-dependent energy analysis, Energy conversion efficiency, Capacity Factor (CF), Renewable energy sources, Non-renewable energy sources, and Conversion efficiency. **(8)** **Mechanical and Thermal system:** Gross Calorific Value (GCV) and Net Calorific Value (NCV), Combustion, Boiler efficiency testing, excess air control, steam distribution and use of steam traps, condensate recovery, flash steam utilization, Furnace efficiency, thermal insulation, Cogeneration, Waste heat recovery, Energy conservation in pumps, fan and blower, Compressed air systems, Refrigeration and air conditioning systems. **(10)** **Electrical System:** Power factor, energy efficient motors, lighting levels, Illuminance, Energy Conservation in cooling tower, Waste heat recovery, Trigeneration, Energy						

	conservation building code. **(5)** **Energy Auditing:** Introduction, Importance of energy audit, uses of energy audit, Basic terms of energy audit, Types of energy audit, Procedure for carrying energy audit, Instruments used for energy audit. **(9)**
Text Books, and/or reference material	**Text Books:** **1.** Energy Management and Conservation Handbook, Frank Kreith and D. Yogi Goswami; CRC Press, Taylor & Francis Group. **2.** Hand book of Energy Efficiency and Renewable Energy; Frank Kreith and D. Yogi Goswami; CRC Press, Taylor & Francis Group. **3.** Guide to Energy Management, Seventh Edition, Barney L. Capehart, Wayne C. Turner, William J. Kennedy; CRC Press, Taylor & Francis Group. 4. Handbook of Energy Audits, Ninth Edition, Albert Thumann, Terry Niehus, and William J. Younger; CRC Press, Taylor & Francis Group.
	Reference Books: 1. Introduction to Power Plant Engineering - P K Nag 2. Energy Management in Buildings Using Photovoltaics, Elena V. M. Papadopoulou; Springer.

Department of Humanities & Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives(PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO441	Shakespearean Comedy	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
NIL		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Learners will be familiarized with the variegated aspects of life depicted in Shakespeare's comedies. • CO2: Learners will be introduced to the sublime beauty of Shakespeare's poetic language. • CO3: Learners will develop the skill of critically appreciating a piece of literary work acknowledged as a classic.						
Topics Covered	• Textual study of any one or two of the following texts: • As You Like It • The Comedy of Errors • Measure for Measure • The Merchant of Venice • A Midsummer Night's Dream • The Tempest • Twelfth Night • The Winter's Tale						
Text Books, and/or reference material	**Suggested Text Books:** Arden Edition of Shakespeare's Plays **Reference Books:** 1. Shakespearean Comedy: H. B. Charlton (Routledge) 2. Shakespearian Comedy: S. C. Sengupta (Oxford UP) 3. A Shakespeare Manual: S C Sengupta (Oxford UP)						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	-	-	-	-	-	3	3	3	3	2	-	3
CO2	-	-	-	-	-	1	1	-	-	2	-	3
CO3	-	-	-	-	-	2	1	3	1	2	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Humanities & Social Sciences						
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours			Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO743	Shakespearean Tragedy	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
NIL		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Learners will be familiarized with the variegated aspects of life depicted in Shakespeare's tragedies. • CO2: Learners will be introduced to the sublime beauty of Shakespeare's poetic language. • CO3: Learners will develop the skill of critically appreciating a piece of literary work acknowledged as a classic.						
Topics Covered	• Textual study of any one or two of the following texts: • Romeo and Juliet • Julius Caesar • Hamlet • Othello • King Lear • Macbeth • Antony and Cleopatra • Coriolanus • Richard II						
Text Books, and/or reference material	**Suggested Text Books:** Arden Edition of Shakespeare's Plays **Reference Books:** 1. Shakespearean Tragedy: A. C. Bradley (Oxford UP) 2. Aspects of Shakespearian Tragedy: S. C. Sengupta (Oxford UP) 3. Shakespeare's History Plays: S C Sengupta (Oxford UP)						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	3	3	3	3	2	-	3
CO2	-	-	-	-	-	1	1	-	-	2	-	3
CO3	-	-	-	-	-	2	1	3	1	2	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO840	Employability Skills and Workplace Communication	**PEL**	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
-		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	**CO1:** Students will develop an elevated sense of job motivation, workplace proficiency and communication for heightened productivity, along with precision in professional ethics aiding in continual learning and improvement.						
Topics Covered	The Course will undertake a detailed study of the following: 1. Introduction to Employability skills 2. Facing Interviews and Negotiating Job offers 3. Leadership and Team Dynamics 4. Advanced Technical Communication and Netiquette 5. Workplace ethics and Professionalism 6. Innovation and Entrepreneurship 7. Emotional intelligence, Adaptability and Resilience 8. Global awareness and Intercultural soft skills 9. Concept of Human Resource Management 10. Investigative Analysis of Case Studies						
Text Books, and/or reference material	Text Books: 1. Soft Skills & Employability Skills – S. Pillai and A. Fernandez 2. Communication Skills – A Workbook – S. Kumar and P. Lata 3. Cases in Business Ethics – Marianne M. Jennings 4. Human Resource Management – S. Gilmore and S. Williams 5. English for Jobseekers – L. Mukhopadhay						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**2**	**2**	**3**	**2**	**3**

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMO851	Nanomaterials: Processing, Characterization and Properties	Width Elective	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
PHC01: Engineering Physics, CYC01: Engineering Chemistry		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Developer		Dr Barna Roy					

Course Outcomes	CO1: Introduction to the basic concept of nanomaterials and nanotechnology CO2: To get an overview of the processing and characterization of nanomaterials CO3: To understand the structure-property co-relation of nanomaterials for various engineering applications
Topics Covered	**Introduction:** Definition of nanomaterials on the basic of dimension. Basic concept of nanotechnology. Types of nanomaterials, uses of nanomaterials, advantage and disadvantage of nanomaterials over the conventional materials. [6h] **Processing of nanomaterials:** Different methods-bottom up and top down approaches, brief discussion and the bulk dimension of the end product. [8 h] **Characterization of nano-materials and nano-structured materials by different techniques.** [8 h] **Properties of nanomaterials:** Mechanical, electrical, magnetic and optical properties of nanomaterials. Comparative studies between the properties of nanomaterials and conventional materials. Structure-property co-relation of nanomaterials. [12 h] **Application of nanomaterials:** Practical engineering applications of nanomaterials. Future of nanomaterials on the basis of current applications. Environmental effect of the usages of nanomaterials. [6 h]
Text Books, and/or reference material	Text Books: 1. Materials Science and Engineering: An Introduction - William D. Callister, Jr., John Wiley & Sons, Inc., 2007 2. Nanomaterials Nanotechnologies and Design – D.L. Schodek, P. Ferreira, M.F. Ashby, Butterworth-Heinemann, 2009 3. Introduction to Nanotechnology – C.P. Poole, F.J. Owens, Wiley Inderscience, 2003

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO853	Electrical Engineering Materials	**PEL**	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
-		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: understand the fundamentals of atomic structure and basic properties of conductors. • CO2: understand the basic properties of dielectric materials along with their applications. • CO3: understand the basic properties of magnetic materials and their applications. • CO4: acquire basic knowledge of superconductors and their applications.						
Topics Covered	**Atomic Structure:** Review of Rutherford's Model and Bohr's Model related to simple Hydrogen atom; Nuclear binding energy and mass defect. Types of bonding and crystal structures, Atomic arrangement in solids, Band theory of solids; Conductors, Insulators and Semiconductors, Conductors: Electrical conductivity of metals, Lorentz theory, free electron theory, electron scattering. Intrinsic materials and alloys. Resistivity of conductors including alloys. Theory of electrical and thermal conduction in solids, temperature dependence of resistivity, skin effect, Hall effect. (12) **Dielectric materials:** Electrical properties of insulating materials: Volume and surface resistivity, dielectric constant, dielectric dissipation factor and dielectric						

	strength. Thermal endurance of insulating materials. Polarization of dielectrics: Non-polar and polar dielectrics; Electronic, relaxation, ionic, dipole and interfacial polarization; Classification of dielectrics by polarization mechanism; Frequency dependence of permittivity and dielectric dissipation factor. Dielectric relaxation, Methods of modelling of dielectric relaxation, Electrets. Types of dielectric materials: Solid insulating materials-glass, mica, porcelain and ceramics-thermoplastics, cross-linking, thermosetting polymers, epoxy resins-silicon-hydrophobic insulators-composite insulators-Paper and pressboards-Oil impregnation-insulating liquids-mineral oil, vegetable oils, synthetic insulating liquids, Degradation of oil-paper insulation, Relaxation phenomenon for composite dielectrics like oil-paper insulation. Gaseous dielectrics: Properties of gases, breakdown phenomena gaseous insulation-air, Sulphur Hexafluoride-Nano dielectric materials as insulation. (16) **Magnetic Materials:** Atomic interpretation of ferromagnetic materials, Atomic exchange force, crystallographic forces, magnetic anisotropy, magnetostriction, Curie-Weiss law, Curie law, Curie temperature of ferromagnetic materials, Soft magnetic material, CRGO, Ni-Fe alloy and applications Hard magnetic materials Alnico, Alcomax and application, Ferrite-ferromagnetic materials and their applications, Piezo-electric materials. (10) **Superconductors:** Theory of super conductivities, critical field, critical current density, transition temperature; normal and superconductivity steps, Types of super conductor, high temperature superconductor and applications. (4)
Text Books, and/or reference material	**Text Books:** 1. Electrical Engineering Material by A. J. Dekker 2. Electrical Engineering Material by B. M. Tareev 3. Dielectric Materials and applications by A. Von Hipple. **Reference Books:** 1. Kuchler, High Voltage Engineering-Fundamentals, Technology and Application, Springer, 2017. 2. K.C Kao, Dielectric Phenomena in solids, Elsevier, 2004.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EEO853	CO1	3					1	2					1
	CO2	3	1	1									1
	CO3	1	2	3									1
	CO4	2	3			1							1