Silicon Institute of Technology
| An Autonomous Institute |

Curriculum Structure and Detailed Syllabus

Bachelor of Technology in Computer Science & Engineering

Department of Computer Science & Engineering
Silicon Institute of Technology
Silicon Hills, Patia, Bhubaneswar - 751024

Effective from Academic Year 2018-19
Build: 1.30 (26-09-2020)

Approval History

ACM#	Date	Resolutions
AC-1	14/08/2018	The curriculum & detailed syllabus of 1st Year, as proposed by the Board of Studies, is provisionally approved by the Academic Council.
AC-2	11/05/2019	The curriculum & detailed syllabus up to 2nd Year, as proposed by the Board of Studies, is approved by the Academic Council.
AC-3	28/09/2019	The amendments to the curriculum as suggested by the Boards of Studies, along with the proposal for provision of Practice School in the 4th year of B.Tech. is approved in principle by the Academic Council.
AC-4	18/08/2020	The curriculum & detailed syllabus up to 4th Year as suggested by the Boards of Studies, along with provision of Practice School in the 4th year is approved by the Academic Council.

Program Outcomes (UG Engineering)

Graduates Attributes (GAs) form a set of individually assessable outcomes that are the components indicative of the graduate's potential to acquire competence to practice at the appropriate level. The Program Outcomes (POs) for UG Engineering programmes defined by NBA are:

PO1. **Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.

PO2. **Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. **Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. **Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. **Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. **The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. **Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. **Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. **Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. **Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Educational Objectives (PEOs)

PEO1. *Fundamental Knowledge & Core Competence*: To provide knowledge of science and engineering fundamentals required for a computer professional and equip them with proficiency of mathematical foundations and algorithmic principles and inculcate competent problem solving ability.

PEO2. *Competency for Real World*: To inculcate the creative ability of designing computer support systems and impart knowledge and skills required to analyze, design, test and implement various software applications.

PEO3. *Professional Skill & Social Responsibility*: To exhibit leadership capability, triggering social and economical commitment and inculcate a sense of responsibility towards community services and environmental protection.

PEO4. *Life-long Learning*: To grow professionally in their career through continued education & training of technical and management skills. Engage in life-long learning and pursue higher studies.

Program Specific Outcomes (PSOs)

PSO1. Apply fundamentals of mathematics, science and engineering knowledge, and hardware and software tools to identify, investigate, design, and implement solutions to complex computing problems.

PSO2. Understand the impact of professional behavior & ethics, and communicate effectively with the engineering community and the society.

PSO3. Engage in life-long learning and work effectively as an individual as well as in a team comprising of professionals from multiple disciplines.

Course Types & Definitions

L	Lecture
T	Tutorial
P	Laboratory / Practical / Sessional
WCH	Weekly Contact Hours
BS	Basic Sciences
HS	Humanities & Social Sciences (including Management)
ES	Engineering Sciences
PC	Professional Core
PE	Professional Elective
OE	Open Elective
MC	Mandatory Course
CC	Compulsory Course
PJ	Summer Internship / Project Work / Seminar
PS	Practice School / Industry Internship
VV	Viva Voce

Contents

Part I

1st Year B. Tech.
(Common to All Branches)

Curriculum Structure

Semester I									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
BS	18BS1T01	Engineering Mathematics-I	3	0	0	3	0	0
BS	18BS1T05/ 18BS1T06	Engineering Chemistry/ Engineering Physics	3	0	0	3	0	0
ES	18ES1T01/ 18ES1T02	Basic Electronics Engineering/ Basic Electrical Engineering	2	0	0	2	0	0
ES	18ES1T03	Computer Programming	3	0	0	3	0	0
HS	18HS1T01	Communicative & Technical English	3	0	0	3	0	0
MC	18NC1T01/ 18NC1T02	Constitution of India/ Environmental Science & Engineering	2	0	0	0	0	0
PRACTICAL									
BS	18BS1L05/ 18BS1L02	Engineering Chemistry Lab/ Engineering Physics Lab	0	0	2	0	0	1
ES	18ES1L04/ 18ES1L05	Manufacturing Practices/ Engineering Graphics	0	0	2	0	0	1
ES	18ES1L01/ 18ES1L02	Basic Electronics Engineering Lab/ Basic Electrical Engineering Lab	0	0	2	0	0	1
ES	18ES1L03	Computer Programming Lab	0	0	4	0	0	2
HS	18HS1L01	Communicative & Technical English Lab	0	0	2	0	0	1
		SUB-TOTAL	**16**	**0**	**12**	**14**	**0**	**6**
		TOTAL	**28**			**20**		

Note: For some courses, the subjects have been mentioned as Subject-1 / Subject-2, i.e., with an OR option. Every student has to study both the subjects, however allocation of these subjects shall alternate between Semesters I and II. For example, if a student has been allocated *Engineering Chemistry* in Semester-I, then he/she will be allocated *Engineering Physics* in Semester-II, and vice-versa. The laboratory subjects will be as per the theory subjects allocated in the applicable semester. The same applies to all other courses provided with an OR option.

Semester II								
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
BS	18BS1T02	Engineering Mathematics-II	3	0	0	3	0	0
BS	18BS1T06/ 18BS1T05	Engineering Physics/ Engineering Chemistry	3	0	0	3	0	0
ES	18ES1T02/ 18ES1T01	Basic Electrical Engineering/ Basic Electronics Engineering	2	0	0	2	0	0
ES	18ES1T05	Data Structures & Algorithms	3	0	0	3	0	0
MC	18NC1T02/ 18NC1T01	Environmental Science & Engineering/ Constitution of India	2	0	0	0	0	0
PRACTICAL								
BS	18BS1L02/ 18BS1L05	Engineering Physics Lab/ Engineering Chemistry Lab	0	0	2	0	0	1
ES	18ES1L05/ 18ES1L04	Engineering Graphics/ Manufacturing Practices	0	0	2	0	0	1
ES	18ES1L02/ 18ES1L01	Basic Electrical Engineering Lab/ Basic Electronics Engineering Lab	0	0	2	0	0	1
ES	18ES1L06	Data Structures & Algorithms Lab	0	0	4	0	0	2
		SUB-TOTAL	**13**	**0**	**10**	**11**	**0**	**5**
		TOTAL	**23**			**16**		

Note: For some courses, the subjects have been mentioned as Subject-1 / Subject-2, i.e., with an OR option. Every student has to study both the subjects, however allocation of these subjects shall alternate between Semesters I and II. For example, if a student has been allocated *Engineering Chemistry* in Semester-I, then he/she will be allocated *Engineering Physics* in Semester-II, and vice-versa. The laboratory subjects will be as per the theory subjects allocated in the applicable semester. The same applies to all other courses provided with an OR option.

Type	Code	Engineering Mathematics - I	L-T-P	Credits	Marks
BS	18BS1T01		3-0-0	3	100

Objectives	The objective of this course is to familiarize the students with the knowledge and concepts of curve tracing, ordinary differential equations and applications, solution of system of linear equations using matrix methods, and Eigen vectors & Eigen values of matrices with applications.
Pre-Requisites	A good knowledge of trigonometry along with basics of differential and integral calculus of one variable and coordinate geometry of two and three dimensions.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Functions and their Graphs, Asymptotes, Curvature & Curve Tracing	**8 Hours**
Module-2	First order ordinary differential equations and applications	**7 Hours**
Module-3	Second order ordinary differential equations and applications to electrical circuits	**12 Hours**
Module-4	Matrix algebra, system of linear equations, rank and inverse of matrices, vector space	**8 Hours**
Module-5	Eigen values and Eigen vectors, complex matrices, diagonalization of matrices	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Narayan and P. K. Mittal, ***Differential Calculus***, Revised Edition, S. Chand & Company, 2014.
T2. E. Kreyszig, ***Advanced Engineering Mathematics***, 8th Edition, Wiley India, 2015.

Reference Books:

R1. S. Pal and S. C. Bhunia, ***Engineering Mathematics***, 1st Edition, Oxford University Press, 2015.
R2. B. V. Ramana, ***Higher Engineering Mathematics***, 1st Edition, McGraw Hill, 2017.

Online Resources:

1. http://www.nptel.ac.in/courses/111105035
2. http://www.nptel.ac.in/courses/122104017
3. http://nptel.ac.in/courses/122102009
4. http://nptel.ac.in/courses/111107063
5. https://www.coursera.org/learn/linearalgebra2
6. https://www.coursera.org/learn/differentiation-calculus
7. https://www.coursera.org/learn/single-variable-calculus
8. https://alison.com/courses/Algebra-Functions-Expressions-and-Equations

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

CO1	Understand the graphs of functions (curves) by knowing their characteristics like asymptotes and curvature and applying those to curve tracing.
CO2	Solve first order ordinary differential equations using various methods and apply them to physical problems.
CO3	Learn methodology to Solve second order ordinary differential equations and apply them to solve applied problems of electrical circuits.
CO4	Develop understanding of the concepts and methods of system of linear equations and apply them to solve a system.
CO5	Study and use the eigen values and eigen vectors of matrices, its properties and applications.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	3	1								2	1	1
CO2	3	3	2	1	2								2	1	1
CO3	3	3	3	3	1								2	1	1
CO4	3	3	3	2	3								2	1	1
CO5	3	3	2	2	2								2	1	1

Type	Code	Engineering Chemistry	L-T-P	Credits	Marks
BS	18BS1T05		3-0-0	3	100

Objectives	The purpose of this course is to emphasize the relevance of fundamentals and applications of chemical sciences in the field of engineering. The contents have been conceived in taking into account appropriate combinations of old and new emerging concepts in the chemical sciences area and their current and potential uses in engineering. The course attempts to address the principles of general chemistry and specific topics relevant to various engineering disciplines, so that the students can apply the knowledge in their respective areas of expertise.
Pre-Requisites	Basic knowledge on Normality, Molarity, mole concept, types of chemical reactions, and elementary idea on electrochemistry.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
	Introduction & Pre-requisites	**2 Hours**
Module-1	**Water Treatments**: Types of hardness-Units, Alkalinity of water and its significance, Softening methods and Numerical problems based on these methods; Membrane-based processes; Dissolved Oxygen, Problems with Boiler feed water and its treatments.	**6 Hours**
Module-2	**Corrosion Science**: Definition and scope of corrosion, Dry and wet corrosion; Direct chemical corrosion, Electrochemical corrosion and its mechanisms; Types of electrochemical corrosion, (differential aeration, galvanic, concentration cell); Typical Electrochemical corrosion like Pitting, Inter-granular, Soil, Waterline; Factors affecting corrosion, Protection of corrosion.	**7 Hours**
Module-3	**Industrial Lubricants**: Lubricants-Concept of tribology; Types of lubricants and Mechanism of lubrication, Physical and Chemical properties of lubricants, Additives of lubricants, Selection of lubricants, Flash Point, cloud point, freezing points of lubricants.	**5 Hours**
Module-4	**Instrumental Techniques**: Fundamentals of Spectroscopy; Principles and applications of molecular spectroscopy (such as UV-visible, IR and microwave).	**6 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	**Energy Sciences**: Types of fuels, Calorific value, Determination of Calorific value, Combustion and its calculations, Solid fuel: Coal analysis (Proximate and ultimate analysis), Elementary ideas on some gaseous fuels (Natural gas, Water gas, Producer gas, LPG) (Synthesis is excluded), Liquid fuels: IC engine fuel, concept of knocking, antiknocking, octane No and cetane No, Fractional Distillation of petroleum, Cracking of heavy oils; Battery technology – Fundamentals of primary & Secondary cells, Rechargeable batteries: Lead acid storage battery, Lithium ion battery, Fuel cells: principles, applications. Elementary idea on Photovoltaics.	**10 Hours**
Module-6	**Nanochemistry**: Nanomaterials, Synthesis of noble metal nanoparticles (e.g., Gold /silver) and oxide based nanoparticles (e.g., cuprous oxide/zinc oxide) using green synthetic route, Stabilization of nanoparticles using capping agents, Elementary ideas on characterization of nanoparticles (X-ray Diffraction (XRD) and electronic spectroscopy), applications of nanomaterials.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. Jain & Jain, ***Engineering Chemistry***, 16th Edition, Dhanpat Rai Publishing Company, 2015.
T2. G. A. Ozin & A. C Arsenault, ***Nanochemistry - A Chemical Approach to Nanomaterials***, RSC Publishing.
T3. C. N. Banwell, ***Fundamentals of Molecular Spectroscopy***, 3rd Edition, McGraw Hill.

Reference Books:

R1. S. S. Dara, ***Engineering Chemistry***, 12th Edition, S. Chand Publisher, 2014.
R2. Wiley-India Editorial Team, ***Engineering Chemistry***, 2nd Edition, Wiley India.
R3. J. M. Lehn, L. Cademartiri, ***Concepts of Nanochemistry***, 1st Edition, Wiley-VCH, 2009.
R4. Y. R. Sharma, ***Elementary Organic Spectroscopy***, S Chand & Co Ltd., 2013.

Online Resources:

1. https://chem.libretexts.org/Core/Analytical_Chemistry/Electrochemistry/Exemplars/Corrosion/Corrosion_Basics
2. https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/spectrpy/infrared/infrared.htm
3. http://nptel.ac.in/courses/103105110/ - Fuel & Combustion
4. http://www.analyticalinstruments.in/home/index.html
5. www.edx.org/
6. https://www.ntnu.edu/studies/courses
7. http://www.corrosionsource.com/
8. http://nptel.ac.in/courses/105104102/hardness.htm
9. http://nptel.ac.in/courses/105106112/1_introduction/5_corrosion.pdf
10. https://alison.com - Spectroscopic Technique, Colorimetry

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

CO1	Exploit the concept of hardness in softening hard water and determining the hardness of water.
CO2	Utilize the knowledge of electrochemistry and corrosion science in preventing engineering equipments from corrosion.
CO3	Understand the characteristics of industrial lubricants, mechanism of lubrication and study kinematic viscosity & flash point of lubricating oil for application in engineering.

Cont'd...

CO4	Understand the concept of molecular spectroscopy and analyze organic compounds using spectrophotometer.
CO5	Classify various fuels based on combustion parameters and understand the working principle of various batteries.
CO6	Acquire knowledge on synthesis & characterization of oxide based & noble metal nanoparticles through green synthetic route.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1	1	2	1	1					2	1	1
CO2	3	2	1	1	1	2	1						2	1	1
CO3	2	2	1	1	1	2	1						2	1	1
CO4	2	2	1	1	2	2	1	1					2	1	1
CO5	2	2	1	1	1	1	1						2	1	1
CO6	2	2	1	1	2	2	1	1					2	1	1

Type	Code	Engineering Physics	L-T-P	Credits	Marks
BS	18BS1T06		3-0-0	3	100

Objectives	The objective of this course is to obtain basic idea about various laws and understand different phenomena using principles of physics. This knowledge will be useful for the engineering students to understand the basic operating principle of instruments and techniques. The knowledge obtained can also be used to prepare various models and projects.
Pre-Requisites	Adequate knowledge and clear concepts in higher secondary physics like waves, oscillations, optics, electricity, magnetism, modern physics, etc.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
	Introduction & Pre-requisites	**2 Hours**
Module-1	**Wave Optics**: Concept of wave and wave equation, Superposition of waves (two beam and multiple beam) and interference, Huygen's principle, Interference by division of amplitude and division of wavefront, Theory of Newton's rings and its applications, Diffraction, Fraunhofer and Fresnel diffraction, Fraunhofer's diffraction from a single slit, Theory of plane diffraction grating, Determination of wavelength of light with a plane diffraction grating.	**10 Hours**
Module-2	**Vector Calculus**: Gradient of scalar field, Divergence and curl of vector field, Gauss divergence theorem and Stokes theorem (statement only). **Maxwell's Equations**: Gauss's law in electromagnetism, Faraday's law of electromagnetic induction, Ampere's circuital law, Displacement current, Maxwell's electromagnetic equations (integral and differential form). **Electromagnetic Waves**: Electromagnetic Wave (EM) equations - Free space, Dielectric and conducting medium, Transverse nature of EM wave, Electromagnetic wave in ionized medium, Electromagnetic energy density, Poynting's theorem and Poynting's vector.	**11 Hours**
Module-3	**Introduction to Quantum Mechanics**: Need of quantum mechanics, Particle nature of radiation - Black body radiation (no derivation), Photoelectric effect, Compton effect and pair production, Concept of de-Broglie's matter waves, Phase and group velocity, Heisenberg's Uncertainty principle with applications.	**6 Hours**
Module-4	**Schrödinger's wave equation with applications**: Concept of wave function ψ and interpretation of $\|\psi\|^2$, Schrödinger's time-dependent and time-independent equations, Probability current, Expectation values, Operators in quantum mechanics, Eigen functions and Eigen values, Applications of Schrödinger's equation- Particle in one dimensional rigid box, Potential barrier (emphasis on tunneling effect).	**6 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	**Laser**: Radiation-matter interaction, Absorption of light, Spontaneous and stimulated emission of light, Population inversion, Types of Laser-Solid State Laser (Ruby), Gas Laser (He-Ne), Properties and applications of Laser. **Optical Fiber**: Structure and Principle, Types of optical fiber, Numerical aperture, Applications of optical fiber.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. D. R. Joshi, ***Engineering Physics***, 1st Edition, Tata McGraw-Hill Publication, 2017.
T2. Md. M. Khan and S. Panigrahi, ***Principle of Physics***, Vol. I & II, Cambridge Univ. Press.

Reference Books:

R1. A. Ghatak, ***Optics***, Tata McGraw Hill.
R2. B. S. Agarwal, ***Optics***, Kedar Nath Rama Nath & Co.
R3. S. Prakash, ***Electromagnetic Theory and Electrodynamics***, Kedar Nath Ram Nath & Co.
R4. D. J. Griffith, ***Introduction to Electrodynamics***, Pearson Education.
R5. R. Eisberg and R. Resnick, ***Quantum Physics of Atoms, Molecules, Solids, Nuclei & Particles***, John Wiley Publications.
R6. A. Beiser, ***Concept of Modern Physics***, McGraw Hill.
R7. R. K. Gour and S. L. Gupta, ***Engineering Physics***, Dhanpat Rai Publications.

Online Resources:

1. https://ocw.mit.edu/courses/physics/8-04-quantum-physics-i-spring-2013/
2. http://www.ilectureonline.com/lectures/subject/PHYSICS
3. https://ocw.mit.edu/courses/physics
4. https://nptel.ac.in/courses/115102026/
5. https://nptel.ac.in/courses/113104012/

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

CO1	Analyze wave properties of light like interference and diffraction and apply them in communications
CO2	Develop Maxwell's equations from basic laws of electromagnetism and apply them to understand the properties of electromagnetic waves.
CO3	Analyze wave-particle duality to understand radiation-matter interaction
CO4	Develop and apply Schrödinger's equations to diverse fields like bound particle, potential barrier etc.
CO5	Investigate the basic principle, properties, operations and applications of laser & optical fibre in different fields like communication, industry, medicine, research etc.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Cont'd...

PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	1								1	3	1	2
CO2	3	2	1	2	1							1	3	1	1
CO3	3	2		1								1	2	1	2
CO4	3	2		1								1	3		1
CO5	3	3	1	2	1							1	3	1	2

Type	Code	Basic Electronics Engineering	L-T-P	Credits	Marks
ES	18ES1T01		2-0-0	2	100

Objectives	Know broadly the concepts and functionalities of the electronic devices, tools and instruments. Understand general specifications and deployability of the electronic devices, and assemblies. Develop confidence in handling and usage of electronic devices, tools and instruments in engineering applications.
Pre-Requisites	Knowledge on intrinsic and extrinsic Semiconductors, Physics and Chemistry of Higher Secondary Science level.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, and planned lectures to make the sessions interactive with problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction to Electronics**: Signals, Frequency spectrum of signals, Analog and digital signals, Amplifiers, Digital logic inverters. (2 Hours) **Diodes and Applications**: Semiconductor Diode - Ideal versus Practical, Resistance Levels, Diode Equivalent Circuits, Load Line Analysis; Diode as a Switch, Diode as a Rectifier, Half Wave and Full Wave Rectifiers, Breakdown Mechanisms, Zener Diode – Operation and Applications; Clipper and Clamper Circuits. Opto-Electronic Devices – LEDs, Photo Diodes and Applications (8 Hours)	**10 Hours**
Module-2	**Bipolar Junction Transistor (BJT)**: Construction, Operation, Amplifying Action, Common Base, Common Emitter and Common Collector Configurations, Operating Point, Fixed and Voltage divider Biasing Configurations.	**5 Hours**
Module-3	**Field Effect Transistor (FET)**: Construction, Characteristics of Junction FET (JFET), Depletion and Enhancement type Metal Oxide Semiconductor FETs (MOSFET), Fixed and Voltage divider Biasing Configurations, Introduction to Complementary MOS (CMOS) circuits.	**5 Hours**
Module-4	**Operational Amplifiers and Applications**: Introduction to Op-Amp, Differential Amplifier Configurations, Basics of Op-Amp, Characteristics of Ideal Op-Amp, CMRR, PSRR, Slew Rate; Block Diagram and Pin Configuration of IC 741 Op-Amp, Applications of Op-Amp as: Summing Amplifier, Difference Amplifier, Differentiator, Integrator.	**4 Hours**
Module-5	**Feedback Amplifiers**: Principle, Advantages of Negative Feedback, Different Feedback Topologies. **Oscillators**: Classification, RC Phase Shift Oscillator, High Frequency LC Oscillator.	**4 Hours**
	Total	**28 Hours**

Text Books:

T1. R. L. Boylestad and L. Nashelsky, ***Electronic Devices and Circuit Theory***, 11th Edition, Pearson Education.

T2. A. S. Sedra and K. C. Smith, ***Microelectronic Circuits***, 7th Edition, Oxford University Press.

Reference Books:

R1. A. Agarwal and J. Lang, ***Foundations of Analog and Digital Electronic Circuits***, 1st Edition, Morgan Kaufmann, 2005.
R2. V. K. Mehta and Rohit Mehta, ***Principles of Electronics***, 3rd Edition, S. Chand Publishing, 1980.

Online Resources:

1. http://www.electrical4u.com/circuit-analysis.htm
2. http://www.allaboutcircuits.com
3. https://www.electronics-tutorials.ws/
4. https://www.edx.org/course/circuits-electronics-1-basic-circuit-mitx-6-002-1x-0

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

CO1	Become familiar with basic signals, diodes and their applications.
CO2	Investigate on the operation of different configurations of bipolar junction transistor. Analyze and design different biasing configurations with their applications.
CO3	Understand the construction, operation and characteristics of JFET and MOSFET. Analyze and design different biasing configurations with their applications.
CO4	Learn the construction and characteristics of Op-Amp and design circuits for various applications using Op-Amp.
CO5	Understand different types of feedback topologies and design various kinds of oscillators.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1										1		
CO2	3	2	3	1									3		
CO3	2	2	2	1									2		
CO4	3		3										3		
CO5	2	1	2										2		

Type	Code	Basic Electrical Engineering	L-T-P	Credits	Marks
ES	18ES1T02		2-0-0	2	100

Objectives	The objective of this course is to introduce the students to basic concepts of electricity and magnetism. The course will cover the basics of DC & AC networks, principle of operation of different electrical machines and measuring instruments. The course will train the students about the basic protection system and safety requirements and will give an overview of the electrical power systems.
Pre-Requisites	Basic knowledge of intermediate Physics, knowledge of basic Mathematics such as Calculus, Ordinary Differential Equations, Matrices etc.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Fundamentals of Electric Circuits: Charge & current, Voltage & current sources, Electrical circuit elements (R, L and C) and their characteristics, Kirchoff's current and voltage laws. Resistive Network Analysis: Node voltage & Mesh current analysis, Node voltage and mesh current analysis with controlled sources, Thevenin theorem, Norton's theorem, Principle of superposition, Maximum power transfer theorem. Transient Analysis: Writing differential equations for circuits, Time-domain analysis of first-order RL and RC circuits.	**8 Hours**
Module-2	Representation of sinusoidal wave forms, Peak and RMS values, Phasor representation, Real, Reactive, and Apparent power, Power factor. Analysis of single-phase AC circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel). Three phase balanced circuits, Voltage and current relations in star and delta connections.	**6 Hours**
Module-3	Electricity and magnetism, Magnetic circuit and magnetic reluctance, Magnetic materials, BH characteristics, Ideal and practical transformer, EMF equation of transformer, Equivalent circuit.	**4 Hours**
Module-4	Construction of DC machines, Generator, Types of excitation system, Working of DC motor, Classification of DC motor, Characteristics and speed control of DC motor. Generation of rotating magnetic fields, Construction and working of a 3-phase induction motor, Torque-slip characteristic. Single-phase induction motor.	**4 Hours**
Module-5	Introduction to Measuring instruments: Different electrical measuring instruments, Energy meters: Connection and elementary calculations for energy consumption. Brief introduction to generation, transmission and distribution of electrical power, Earthing & electrical safety.	**3 Hours**
	Total	**28 Hours**

Text Books:

T1. E. Hughes, ***Electrical & Electronic Technology***, 9th Edition, Pearson, 2004.
T2. G. Rizzoni, ***Principles and Applications of Electrical Engineering***, 5th Edition, McGraw Hill, 2006.

Reference Books:

R1. A. E. Fitzgerald, D. E. Higginbotham, and A. Grabel, ***Basic Electrical Engineering***, 5th Edition, Tata McGraw Hill.
R2. B. L. Theraja and A. K. Theraja, ***Textbook of Electrical Technology (Vol-I)***, 23rd Edition, S. Chand & Co.Ltd., 2002.
R3. L. S. Bobrow, ***Foundations of Electrical Engineering***, Asian Edition, Oxford Univ. Press, 2013.

Online Resources:

1. https://www.slideshare.net/billylui/lecture-1-fundamental-of-electricity
2. https://www.tutorialspoint.com/gate_syllabus/gate_electrical
3. https://www.tutorialspoint.com/theory_of_machines
4. https://www.smartzworld.com/notes/electrical-measurements-em
5. https://lecturenotes.in/subject/113/electrical-power-transmission
6. https://nptel.ac.in/courses/108108076/
7. https://www.electrical4u.com/

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

CO1	Understand and analyze basic electrical network with DC source.
CO2	Measure current, voltage and power of series RLC circuit excited by single-phase AC circuit.
CO3	Develop understanding of different concepts of magnetic fields and apply it to single phase transformer.
CO4	Study the working principles of rotating electrical machines.
CO5	Become familiar with the components of low-voltage electrical installations and different measuring instruments.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	2									3	1	
CO2	3	3	2	3									3	1	
CO3	3	2	1	1				2					3		
CO4	3	2	2										3		
CO5	3	3	2	1									3	1	

Type	Code	Computer Programming	L-T-P	Credits	Marks
ES	18ES1T03		3-0-0	3	100

Objectives	The objective of this course is to introduce fundamentals of computer programming using the C programming language to the students. Starting with simple programs, the course will cover advanced topics like structures, pointers, file processing and pre-processor directives etc. and enable the students to write programs using C language for solving various engineering problems.
Pre-Requisites	Basic analytical and logical understanding including basic knowledge and usage of computers is required for this course. Prior experience with any other programming language will be beneficial.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to computers and programming, operating system, compilers, interpreters, algorithm, flowchart, pseudocode etc., structure of C program, character set, identifier, keywords, constants, variables, data types, operators, expressions, statements, operator precedence and associativity, type conversion, input/output statements.	**8 Hours**
Module-2	Decision making and branching: if, if-else, nested if-else, else-if ladder and switch constructs, iterative execution of code using loops: while, for, do-while, nested loops, controlling loop behavior using jump statements (break, continue, goto) and exit statements.	**8 Hours**
Module-3	Arrays (1-D & 2-D), declaration and initialization of arrays, accessing array elements, operations on arrays - insertion, deletion, searching, sorting (selection sort), merging etc., character arrays and strings, initialization, input & output of strings, operations on strings, array of strings, string handling functions.	**9 Hours**
Module-4	User-defined functions, declaration and definition, parameter passing by value, functions returning values, idea on call by reference, passing arrays to functions, recursion, storage classes - auto, register, static, extern, Structures and Unions - definition, initialization, accessing members, array of structures, arrays within structures, structures and functions, self-referential structures.	**9 Hours**
Module-5	Understanding pointers, declaration, initialization, accessing variables using pointers, pointer expressions, scale factor, chain of pointers, using pointers with arrays, strings, functions and structures, dynamic memory management, pre-processor directives, command line arguments, basics of file handling.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. E. Balagurusamy, ***Programming in ANSI C***, 7th Edition, McGraw-Hill Education, 2017.
T2. Y. Kanetker, ***Let Us C***, 16th Edition, BPB Publications, 2018.

Reference Books:

R1. B. W. Kernighan and D. M. Ritchie, ***The C Programming Language***, 2nd Edition, Pearson Education, 2015.
R2. H. Schildt, ***C: The Complete Reference***, 4th Edition, McGraw-Hill, 2017.
R3. A. Kelley and I. Pohl, ***A Book on C***, 4th Edition, Pearson Education, 2008.
R4. B. Gottfried, ***Schaum's Outline of Programming with C***, 3rd Edition, McGraw-Hill, 2017.

Online Resources:

1. http://www.stat.cmu.edu/~hseltman/c/CTips.html
2. http://www.c-faq.com/
3. https://www.learn-c.org/
4. https://www.javatpoint.com/c-programming-language-tutorial
5. http://www2.its.strath.ac.uk/courses/c/

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

CO1	Formulate logic of a problem and write C programs using variables, expressions and input/output statements.
CO2	Develop structured C programs involving decision making using different control constructs.
CO3	Solve problems involving similar set of data items and convert them into C programs using arrays.
CO4	Design modular C programs and handle heterogeneous data items using structures & unions.
CO5	Write C applications using pointers, pre-processor directives, command line arguments and files.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1								1	3		2
CO2	3	3	2	2								1	3		2
CO3	3	3	2	2								1	3		2
CO4	3	2	2	2								1	3		2
CO5	3	3	2	3								1	2		2

Type	Code	Communicative & Technical English	L-T-P	Credits	Marks
HS	18HS1T01		3-0-0	3	100

Objectives	The objectives of this course are to develop the students' communication skills with proficiency in Technical English, to make them aware of the importance of cross-cultural communication, to develop analytical skills to read and comprehend texts, and to help compose effective business messages.
Pre-Requisites	Basic knowledge of English grammar and the ability to read and write using the English language.
Teaching Scheme	Regular classroom lectures with the use of PPTs as and when required; sessions are planned to be interactive with focus on improving spoken and written communication skills in English.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Elements of Technical Communication**: General vs Technical Communication; Factors, participants, code, channels, message, feedback, Effective Business Communication; Importance of technical communication; Communication across cultures and common problems; Barriers to effective communication.	**6 Hours**
Module-2	**Sounds of English**: vowels, diphthongs, consonants and consonant clusters, problem sounds, phonemic transcription, syllabic division and stress, weak forms and rhythm, intonation.	**5 Hours**
Module-3	**Effective Business Communication**: Structure of a business organization; purpose of business organization; Technology in communication; use of bias-free language; channels of communication: upward, downward, diagonal, grapevine, open door communication; forms of technical communication: internal, external, formal, informal, oral, written. Language structures for day-to-day business communication: persuasion, negotiation, argumentation, making suggestions, assertive communication. Public speaking and presentation skills; content development; clarity of speech; emotions displayed by body language, personal space and zones, personal appearance and attitude to time.	**9 Hours**
Module-4	**Critical Reading**: sub-skills of reading; reading a feature article; reading an editorial; skimming through a short report; reading contemporary essays; reading prescribed English short stories.	**11 Hours**
Module-5	**Effective Business Writing**: constituents of effective writing: ; paragraph development: coherence, cohesion, progression of ideas, elements of style, clarity and precision, avoiding redundancy, circumlocution, jargons; Dealing with positive and negative messages; business writing: writing a memo; writing an e-mail, writing business letters, notice, writing different types of reports, writing a proposal.	**11 Hours**
	Total	**42 Hours**

Text Books:

T1. M. A. Rizvi, ***Effective Technical Communication***, McGraw Hill.
T2. T. Balasubramaniam, ***English Phonetics for Indian Student***, Trinity Press.
T3. B. K. Das, ***An Introduction to Professional English and Soft Skills***, Cambridge Univ. Press, 2009.
T4. D. K. Das, A. Kumari, K. K. Padhi, ***Anthology of Modern English Prose***, Triniti Press.

Reference Books:

R1. S. Samantray, ***Business Communication and Communicative English***, S. Chand & Co.
R2. J. Seeley, ***The Oxford Guide to Writing and Speaking***, Oxford Univ. Press.
R3. B. K. Mitra, ***Communication Skills for Engineers***, Oxford Univ. Press, 2011.
R4. M. Raman, S. Sharma, ***Technical Communication: Principles & Practice***, Oxford Univ. Press.

Online Resources:

1. http://www.cambridgeindia.org
2. http://www.cambridgeenglish.org/exams/business-certificates/business
3. https://steptest.in
4. https://www.coursera.org/specializations/business-english
5. http://www.academiccourses.com/Courses/English/Business-English

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

CO1	Understand the elements of technical communication and communication across cultures.
CO2	Learn about aspects of English pronunciation and speak using a neutral accent.
CO3	Learn about the channels of business communication and business hierarchies in order to communicate effectively in a business set up.
CO4	Enhance their reading skills and be able to critically analyse texts of various kind.
CO5	Compose different types of business correspondences effectively.

Program Outcomes Relevant to the Course:

PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1								1	2	3	2	3		3	3
CO2									1	3	1	3		3	1
CO3								1	3	3	2	3		3	2
CO4										3		3		1	2
CO5								2	1	3	1	3		3	2

Type	Code	Constitution of India	L-T-P	Credits	Marks
MC	18NC1T01		2-0-0	0	100

Objectives	The objective of this subject is to provide understanding of the basic concepts of Indian Constitution and various organs created by the constitution including their functions. The course acquaints students with the constitutional design of state structures and institutions, and their actual working over time.
Pre-Requisites	Basic knowledge of Indian history, overall idea on India's political system.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required and each session is planned to be interactive.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Indian Constitution, Historical perspective of the constitution of India. Preamble of Indian constitution, Salient features of Indian constitution, Fundamental rights, Fundamental Duties and its legal status, Directive principles of state policy-its importance and Implementation.	**8 Hours**
Module-2	Federal structure and distribution of legislative and financial powers between the Union and the States, The Union legislature - The Parliament - The Lok Sabha and the Rajya Sabha, Composition, powers and functions, Union executive, President of India (with powers and functions), Vice-President, The Council of Ministers and the Prime Minister - Powers and functions.	**6 Hours**
Module-3	State Government, The State Legislature - composition, powers and functions, State executive, Governor (with powers and functions).	**5 Hours**
Module-4	Amendment of the Constitutional Powers and Procedure, Emergency Provisions : National Emergency, President Rule, Financial Emergency. Scheme of the Fundamental Right to Equality Scheme of the Fundamental Right to certain Freedom under Article 19, Scope of the Right to Life and Personal Liberty under Article 21. Local Self Government - Constitutional Scheme in India.	**5 Hours**
Module-5	The Indian Judicial System - the Supreme Court and the High Court's composition, jurisdiction and functions, Judicial review, Judicial activism, independence of Judiciary in India.	**4 Hours**
	Total	**28 Hours**

Text Books:

T1. D. D. Basu, ***Introduction of Constitution of India***, 22nd Edition, LexisNexis, 2015.
T2. K. Subas, ***An Introduction to India's Constitution and Constitutional Law***, 5th Edition, National Book Trust India, 2011.

Reference Books:

R1. M. Laxmikanth, ***Indian Polity***, 5th Edition, McGraw Hill, 2011.
R2. P. M. Bakshi, ***The Constitution of India***, 14th Edition, Universal Law Publishing Co, 2006.

Online Resources:

1. https://www.india.gov.in/sites/upload_files/npi/files/coi_part_full.pdf
2. https://www.india.gov.in/my-government/constitution-india/constitution-india-full-text
3. https://www.tutorialspoint.com/indian_polity/indian_polity_tutorial.pdf
4. https://www.careerpower.in/wp-content/uploads/2016/03/SSC-POLITY-CIVICS-CAPSULE-2016.pdf

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

CO1	Provide basic information about Indian constitution and to analyze the legalities and related issues of drafting, adoption and enforcement of the Indian Constitution as a fundamental law of the nation and the provisions and privileges of Indian Citizenship.
CO2	Understand and judiciously use the fundamental rights and privileges envisaged in the constitution propagating social harmony and equality and respecting the rights and liberties of other people.
CO3	Analyze the major dimensions of Indian Political System and to contribute in protecting and preserving the sovereignty and integrity of India.
CO4	Know the successful functioning of democracy in India and to respect the Constitutional Institutions like Judiciary, Executive and Legislature.
CO5	Understand their obligations, responsibilities, privileges & rights, duties and the role that they have to play in deciding the Administrative Machinery of the country.

Program Outcomes Relevant to the Course:

PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1				1		2	1	1	1					1	2
CO2						2	1	1	1					1	2
CO3						3	1	1	1					1	1
CO4						2	1	1	1					1	2
CO5						2	1	2	1					1	2

Type	Code	Environmental Science & Engineering	L-T-P	Credits	Marks
MC	18NC1T02		2-0-0	0	100

Objectives	This course serves as a general introduction to environmental science. From ecology and ecosystems, it acquaints the students to air & water quality and the impact of pollution on the environment due to industries and urbanization. Some remediation methods of minimizing the impact of pollutants through technology and legal systems are also addressed.
Pre-Requisites	Basic knowledge of physics, chemistry and biology is required for this course.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required and some sessions are planned for expert talk, seminar presentation by students.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Ecology & Biogeochemical Cycles: Introduction to environmental science, ecological perspective and value of environment, biodiversity of species, biotic components, energy, food chain, biogeochemical cycles like water, oxygen, nitrogen and carbon cycle.	**5 Hours**
Module-2	Environmental gradients & Laws: Environmental gradients, tolerance levels of environment factors, Indian environmental laws and activities including seminar presentations by students.	**4 Hours**
Module-3	Water & Wastewater Treatment: Water quality standards and parameters, pre-treatment and conventional treatment processes of water, DO, BOD, COD, wastewater treatment.	**4 Hours**
Module-4	Atmospheric chemistry, soil chemistry, ground water recharge, noise source & abatement: atmospheric chemistry, air pollution, climate change, soil chemistry, water table and aquifer, ground water recharge, noise standards, noise measurement, noise control and activities including expert talk.	**5 Hours**
Module-5	Solid Waste & Hazardous Waste Management: Source, classification and composition of MSW, MSW management, 3R principles, hazardous waste generation and their management, environment impact assessment, origin & procedure of EIA, project screening for EIA, scope studies, preparation and review of EIS.	**5 Hours**
Module-6	Environment and Human Health: Environment and human health, the impact of the IT industry on the environment including e-waste, activities including presentation & report submission on environmental problems.	**5 Hours**
	Total	**28 Hours**

Text Books:

T1. G. M. Masters and W. P. Ela, ***An Introduction to Environmental Engineering and Science***, PHI.
T2. G. Kiely, ***Environmental Engineering***, Intl. Edition, McGraw Hill.

Reference Books:

R1. M. L. Davis and S. J. Masten, ***Principles of Environmental Engineering and Science***, Intl. Edition, McGraw-Hill.
R2. H. D. Kumar and U. N. Dash, ***Environmental Studies***, IndiaTech Publishers.

Online Resources:

1. http://nptel.ac.in/courses/120108002/: Aquatic Biodiversity and Environmental Pollution.
2. http://nptel.ac.in/courses/120108004/: Environment Management.
3. http://nptel.ac.in/courses/120108005/: Municipal Solid Waste Management.
4. https://www.epa.gov/environmental-topics/: All Current Environmental Issues.

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

CO1	Apply concepts of ecology, eco systems, food chain and biogeochemical cycles for better understanding of functions of the environment.
CO2	Understand environmental gradients, tolerance levels and environmental laws for prevention of environmental pollution.
CO3	Enhance knowledge of water and wastewater treatment for prevention of water pollution.
CO4	Understand the chemistry of pollutants in the atmosphere, soil and groundwater and understand principles of noise abatement.
CO5	Enhance knowledge of waste minimization technique to minimize and manage solid, hazardous wastes generated in different areas.
CO6	Understand the role of IT and human health, and the issues of e-waste management.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1					2	3	1	2		1			2	1
CO2	1					3	3	3	2		1			2	2
CO3	1					2	2	2	2		1			2	2
CO4	1					1	2	1	1		1			2	2
CO5	1					2	3	1	2		1			2	2
CO6	1					3	3	3	2		1			3	3

Type	Code	Engineering Mathematics - II	L-T-P	Credits	Marks
BS	18BS1T02		3-0-0	3	100

Objectives	The objective of this course is to familiarize the perspective engineers with the knowledge and concepts of probability and statistics which are essential to study non-deterministic systems.
Pre-Requisites	Basics of sets, counting techniques, differential and integral calculus of one variable and coordinate geometry of two and three dimensions.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Laplace transform, Inverse Laplace transform, shifting theorems, Transform of derivatives and integrals, Unit step function and Dirac delta function, applications to differential equations.	**7 Hours**
Module-2	Differentiation & Integration of Transforms, Convolution and integral equations, Use of partial fraction, system of differential equations.	**7 Hours**
Module-3	Random Experiment & Probability, Conditional Probability, Bayes' Rule, Random variable & Probability Distribution, Mean, Variance.	**8 Hours**
Module-4	Uniform Discrete Distributions: Binomial, Poisson, Hyper geometric, Geometric Random Variable, Continuous Uniform Distribution: Normal Distribution, Exponential Distribution.	**8 Hours**
Module-5	Joint Distribution, Covariance, Sampling & sampling distributions, maximum likelihood estimation, Estimation of mean, Confidence Interval of mean, difference of two means, variance.	**7 Hours**
Module-6	Testing of Hypothesis about mean, two means and variance, Testing goodness of fit, Linear regression, least square line, correlation coefficient.	**5 Hours**
	Total	**42 Hours**

Text Books:

T1. E. Kreyszig, ***Advanced Engineering Mathematics***, 8th Edition, Wiley India, 2015.

Reference Books:

R1. S. Pal and S. C. Bhunia, ***Engineering Mathematics***, 1st Edition, Oxford University Press, 2015.
R2. B. V. Ramana, ***Higher Engineering Mathematics***, 1st Edition, MC Graw Hill, 2017.

Online Resources:

1. http://www.nptel.ac.in/courses/111105035/32
2. http://www.nptel.ac.in/courses/122104017
3. http://nptel.ac.in/courses/122102009
4. www.edx.org/Probability
5. https://ocw.mit.edu/courses/.../18-440-probability-and-random-variables-spring-2014/

6. https://ocw.mit.edu/courses/mathematics/18-03sc-differential-equations-fall-2011/unit-iii-fourier-series-and-laplace-transform/laplace-transform-basics/

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

CO1	Study and use the concepts of probability and random variables and applying them to evaluate probabilities of different events.
CO2	Know different discrete and Continuous probability models and apply those to solve probability problems of day to day activities.
CO3	Understand the applications of joint & sampling distributions.
CO4	Learn methodology to apply statistical testing and regression.
CO5	Study the concepts of Laplace Transform and to apply those for solving ODE.
CO6	Develop understanding of convolution and its application to integral equations.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2								3	1	1
CO2	3	3	3	3	3								3	1	1
CO3	3	2	3	2	2								2	1	1
CO4	3	3	3	3	2								2	1	1
CO5	3	3	2	2	3								2	1	1
CO6	3	3	2	2	3								2	1	1

Type	Code	Data Structures & Algorithms	L-T-P	Credits	Marks
ES	18ES1T05		3-0-0	3	100

Objectives	To understand the abstract data types and to solve problems using data structures such as stacks, queues, linked lists, hash tables, binary trees, heaps, binary search trees, graphs and writing programs for these solutions.
Pre-Requisites	Knowledge of programming in C, specifically on structures, pointers, functions, recursion etc., are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to data structures, classification of data structures, algorithmic notation, complexity of algorithms, asymptotic notations, abstract data types. Arrays - introduction, representation of arrays (row and column major representation), basic operations on array (traverse, insert, delete, search), sparse matrix, representation of sparse matrix using triplet form, operations on sparse matrix (addition, transpose)	**8 Hours**
Module-2	ADT Stack - stack model, representation of stack using array, basic operations with analysis, applications- recursion, and conversion of infix to post fix expression, evaluation of postfix expression. ADT Queue - queue model, representation using array, basic operations with analysis, circular queue, introduction to priority queue and double ended queue.	**8 Hours**
Module-3	Linked list - introduction, types of linked list (single, double, circular), representation in memory, operations on linked list (traverse, search, insert, delete, sort, merge) in each type with analysis. Representation of polynomial and its operations (addition, multiplication), implementation of stack and queue using linked list.	**9 Hours**
Module-4	Tree - terminology, representation, binary tree - tree traversal algorithms with and without recursion. Binary search tree, Operations on Binary Search Tree with analysis, threaded binary tree, general tree, Height balanced tree (AVL tree), m-way search trees, B-trees. Graph - terminology, representation (adjacency matrix, incidence matrix, path matrix, linked representation), graph traversal (BFS, DFS), Dijkstra's single source shortest path algorithm, Warshall's all pair shortest path algorithm, topological sort.	**9 Hours**
Module-5	Sorting algorithms - bubble sort, selection sort, insertion sort, quick sort, merge sort, radix sort, heap sort. Hashing- hash functions and hashing techniques. collision resolution techniques- linear probing, quadratic probing, chaining.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. E. Horowitz, S. Sahni, S. Anderson-Freed, ***Fundamentals of Data Structures in C***, 2nd Edition, Universities Press, 2008.
T2. M. A. Weiss, ***Data Structures and Algorithm Analysis in C***, 2nd Edition, Pearson Education, 2002.

Reference Books:

R1. A. M. Tenenbaum, Y. Langsam, and M. J. Augenstein, ***Data Structures Using C***, 3rd Edition, Pearson Education, 2007.
R2. J. P. Tremblay and P. G. Sorenson, ***An Introduction to Data Structures with Applications***, 2nd Edition, McGraw Education, 2017.
R3. S. Lipschutz, ***Data Structures***, 1st Revised Edition, McGraw Education, 2014.

Online Resources:

1. http://nptel.ac.in/courses/106102064/1
2. http://www.nptelvideos.in/2012/11/programming-and-data-structure.html
3. https://www.tutorialspoint.com/data_structures_algorithms/index.htm
4. https://www.coursera.org/learn/data-structures/
5. https://www.geeksforgeeks.org/data-structures/

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

CO1	Analyze performance of algorithms and implement various operations on array and sparse matrix.
CO2	Apply the basic operations of stacks and queues to solve real world problems.
CO3	Implement different types of linked list operations and their applications.
CO4	Represent data using trees & graphs to use them in various real life applications.
CO5	Analyze various sorting algorithms and explore different hashing techniques.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	2		1						1	3		3
CO2	3	3	3	2		1						1	3		3
CO3	3	3	3	2		1						1	3		3
CO4	3	2	3	3		2						1	3		3
CO5	3	3	3	3		1						1	3		3

Type	Code	Engineering Chemistry Lab	L-T-P	Credits	Marks
BS	18BS1L05		0-0-2	1	100

Objectives	Objectives of the subject is to educate the students with modern instrumental techniques & role of chemical analysis in various fields of engineering and science to examine and understand the effect of chemicals, compositions, impurities etc., on the properties of materials & the detrimental effects of polluting materials, and other unwanted impurities.
Pre-Requisites	Student should have the knowledge of balancing equations, principle of titrations, titrant, titrand, preparation of standard solutions, concentration of a solution, indicators used in a titration, principle of reduction-oxidation reactions, handling of instruments like pH meter & accurate measurement of sample by using electronic balance.
Teaching Scheme	Regular laboratory experiments conducted under supervision of the teacher. Demonstration will be given for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Determination of Total hardness of water sample by EDTA method.
2	Determination of alkalinity of water.
3	Determination of available chlorine of bleaching powder/residual chlorine in tap water.
4	Determination of dissolved oxygen in supplied water.
5	Determination of saponification value of oil.
6	Determination of Acid value of oil.
7	Determination of Flash-point/fire point of a lubricant by Pensky-Martein's apparatus.
8	Determination of kinematic viscosity and Viscosity Index of a lubricant by Redwood viscometer.
9	Determination of concentration of a colour substance by Spectrophotometer.
10	Green synthesis of noble metal/oxide based nanoparticles.
11	Estimation of calcium in limestone powder.
12	Determination of chloride content of water.
13	Determination of the partition coefficient of a substance between two immiscible liquids.
14	Adsorption of acetic acid by charcoal.
15	Use of the capillary viscosimeters to the demonstrate of the isoelectric point as the pH of minimum viscosity for gelatin solutions and/or coagulation of the white part of egg.
16	Proximate analysis of coal sample.
17	Determination of iodine value of oil/fat.

Text Books:

T1. Jain & Jain, ***Engineering Chemistry***, 16th Edition, Dhanpat Rai Publishing Company, 2015.
T2. S. S. Dara, ***Engineering Chemistry***, 12th Edition, S. Chand Publisher, 2014.

Reference Books:

R1. S. Chawla, ***Essentials of Experimental Engineering Chemistry***, Dhanpat Rai & Co.
R2. S. K. Bhasin and S. Rani, ***Laboratory Manual on Engineering Chemistry***, 3rd Edition, Dhanpat Rai & Co, 2012.

Online Resources:

1. https://www.metrohm.com/en/industries/petro-lubricants/: Lubricant analysis according to international standards
2. http://www.eco-web.com/edi/01759.html: Efficient Wastewater Treatment: The field for analytical and monitoring

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

CO1	Analyse various water quality parameters such as alkalinity, hardness, dissolved oxygen & chloride content before it is put into use in various general, research, or industrial purposes.
CO2	Test the quality of an oil/fat by measuring its iodine or acid value by means of amount of unsaturation for various industrial use.
CO3	Verify quality of a lubricant by means of its viscocity or flash point which gives their nature & flammability for various industrial applications.
CO4	Analyse various fractions present in coal by proximate analysis for better use of carbon based compounds in industrial applications.
CO5	Study the importance of green synthesis by way of synthesising metal/ metal oxide based nano-particles for various material applications.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

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PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2		1	2		1		2	1			2	1	1
CO2	2	2		1	2		2		2	2			1	1	1
CO3	3	2		1	2		1		2	2			1	1	1
CO4	3	3		1	1		2		2	2			2	1	1
CO5	3	2		1	1		1		1	1			2	1	1

Type	Code	Engineering Physics Lab	L-T-P	Credits	Marks
BS	18BS1L02		0-0-2	1	100

Objectives	The objective of this course is to develop the basic practical skill to design and measure different parameters of a physical quantity with proper error analysis which can help them in different field of engineering sciences. This practical knowledge will be useful for the engineering students to understand the basic operating principle of instruments. The knowledge obtained can also be used to prepare various models and projects.
Pre-Requisites	Adequate practical knowledge in Higher Secondary Physics including measuring instruments like screw gauge, slide caliper, spherometer etc. Knowledge of error analysis, graphical analysis etc. is also required.
Teaching Scheme	Regular laboratory experiments conducted under supervision of the teacher. Demonstration will be given for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Determination of bandgap of semiconductor.
2	Determination of rigidity modulus by static method.
3	Determination of surface tension by capillary rise method.
4	Determination of acceleration due to gravity by bar / Kater's pendulum.
5	Determination of Plank's constant, verification of inverse square law by photocell.
6	Determination of wavelength of light by Newton's ring apparatus.
7	Determination of grating element of a diffraction grating.
8	Plotting of characteristic curve of a PN junction diode.
9	Plotting of characteristic curves of BJT.
10	Verification of laws of vibration of stretched string using sonometer.
11	Determination of wavelength of laser source by diffraction grating method.
12	Study of Hall effect.
13	Study of RC circuit.
14	Determination of Young's modulus by bending of beams.
15	Michelson Interferometer.
16	Determine of reduction factor of the given tangent galvanometer and horizontal component of Earth's magnetic field using tangent galvanometer.

Text Books:

T1. C. L. Arora, ***B.Sc. Practical Physics***, 20th Edition, S.Chand & Co.Ltd, 2009.
T2. S. Srivastava, ***Practical Physics***, 3rd Edition, New Age International, 2017.

Reference Books:

R1. H. Singh, ***B.Sc. Practical Physics***, S. Chand & Co.Ltd, 2002.

R2. B.Mallick, S. Panigrahi, ***Engineering Practical Physics***, Cengage Learning, 2015.

Online Resources:

1. https://nptel.ac.in/courses/122103010/
2. https://www.practicalphysics.org/
3. http://www.bsauniv.ac.in/: Search for PHYSICS-LAB-MANUAL2017-(new-regulation).pdf
4. https://arxiv.org/ftp/arxiv/papers/1510/1510.00032.pdf

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

CO1	Analyze the wave aspect of light like interference and diffraction by conducting Newton's rings and Fraunhofer diffraction experiment.
CO2	Investigate some properties of matter like surface tension of water (capillary rise method) and coefficient of elasticity of steel, copper.
CO3	Verify and analyze the IV characteristics of junction diode and BJT, charging and discharging of capacitor in RC circuit.
CO4	Study and apply Hall effect to calculate the Hall coefficient, carrier concentrations; measure band gap of semiconductor and dielectric constant of dielectric material.
CO5	Understand and verify laws of transverse vibrations in a stretched string using sonometer.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2		2								1	3	1	1
CO2	2	2		1	1							1	2		1
CO3	2	1		2									2	1	1
CO4	2	2		3	1								3		1
CO5	3	1		1								1	2		1

Type	Code	Manufacturing Practices	L-T-P	Credits	Marks
ES	18ES1L04		0-0-2	1	100

Objectives	The objective of this practical course is to provide the basic concepts about tools used in manufacturing practices. Detailed concepts are proposed in all the major trades of engineering interest.
Pre-Requisites	None
Teaching Scheme	Regular manufacturing jobs using tools under supervision of the teacher. Demonstration will be given for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Introduction of fitting practice and tools used in fitting jobs.
2	Exercise involving measuring, marking, cutting and filing practice.
3	Fitting of male and female mating parts.
4	Introduction of Lathe, exercise involving facing, straight turning, step turning, taper turning and thread cutting in Lathe machine.
5	Introduction of Milling and Shaping machines.
6	Preparing single step on a square block in Milling machine.
7	Preparing a key way on a square block in Shaping machine.
8	Introduction to basic principles of Arc and Gas welding.
9	Preparing lap joint by Gas welding and butt joint by Arc welding.
10	Sheet metal forming and joining operations.

Text Books:

T1. P. Kannaiah and K. L. Narayana, ***Workshop Manual***, Sceitech Publishers, 2009.
T2. S. K. Hajra Choudhury, ***Elements of Workshop Technology***, Vol-1 and Vol-2, MPP..

Reference Books: *There are no reference books for this subject.*

Online Resources:

1. http://www.technicaltrainingsolutions.co.uk/courses/bench-fitting-course.html
2. http://nptel.ac.in/courses/112101005/14 (Sheet Metal Forming Processes)
3. http://nptel.ac.in/downloads/112105127 (Machining Processes)
4. http://nptel.ac.in/courses/112107144/27 (Welding Processes)

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

CO1	Study and practice use of hand tools and their operations in a fitting shop.
CO2	Design and model various basic prototypes in fitting, such as a Paper weight.
CO3	Design and model and use of various suitable tools form a chining processes like facing, straight turning, step turning, taper turning and thread cutting.

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CO4	Identify and use suitable tools for cutting of a mild steel work piece with the help of shaping and milling machines.
CO5	Design and model various basic prototypes in welding such as a Lap joint and Butt joint.
CO6	Design and model various basic prototypes using sheet metal forming and joining operations.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1		1			1			3		3	2		1	2
CO2	1		2			1			3		3	2		1	2
CO3	1		2			1			3		3	2			2
CO4	1		2			1			3		3	2		1	2
CO5	1		2			1			3		3	2		1	2
CO6	1		2			1			3		3	2		1	2

Type	Code	Engineering Graphics Lab	L-T-P	Credits	Marks
ES	18ES1L05		0-0-2	1	100

Objectives	To create awareness and emphasize the need for Engineering Graphics in all the branches of engineering, to follow basic drawing standards and conventions, to develop skills in three-dimensional visualization of engineering component, to solve specific geometrical problems in plane geometry involving lines, plane figures and special curves, to produce orthographic projection of engineering components working from pictorial drawings.
Pre-Requisites	Basic understanding of Geometry
Teaching Scheme	Regular laboratory classes using drawing tools under supervision of the teacher. Demonstration will be given for each drawing assignment using ICT as when required.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Principles of Engineering Graphics and their significance, usage of various drawing instruments, lettering, dimensioning principles.
2	Conics and Engineering Curves.
3	Orthographic Projections: Principles of orthographic projections - conventions, projections of points and lines.
4	Auxiliary projection Technique: Projection of Points and lines on Auxiliary Planes.
5	Projections of Planes: projections of planes in simple position & inclined to both planes.
6	Projection of Solids: projection of solids in simple position & inclined to both planes.
7	Principles of Isometric projection, isometric scale, isometric views, conventions, isometric views of lines & planes.
8	Isometric projections of solids, conversion of isometric views to orthographic views.
9	Development of surface and intersection of surfaces.
10	Sections and sectional views of simple and compound solids.
11	Introduction to AUTOCAD tools.

Text Books:

T1. N. D. Bhat, M. Panchal, ***Engineering Drawing***, Charotar Publishing House, 2008.
T2. M. B. Shah, B. C. Rana, ***Engineering Drawing and Computer Graphics***, Pearson Education, 2008.
T3. R. K. Dhawan, ***A Text Book of Engineering Drawing***, S. Chand Publications, 2007.
T4. K. L. Narayana, P. Kannaiah, ***Text Book on Engineering Drawing***, Scitech Publishers, 2008.

Reference Books:

R1. T. E. French, C. J. Vierck, R. J. Foster, ***Graphic Science and Design***, 4th Edition, McGraw-Hill.
R2. W. J. Luzadder, J. M. Duff, ***Fundamentals of Engineering Drawing***, 11th Edition, PHI, 1995.
R3. K. Venugopal, ***Engineering Drawing and Graphics***, 3rd Edition, New Age International, 1998.

Online Resources:

1. http://nptel.ac.in/courses/112103019
2. https://freevideolectures.com/course/3420/engineering-drawing
3. http://www.engineeringdrawing.org/
4. https://ocw.mit.edu/courses/mechanical-engineering/2-007-design-and-manufacturing-i-spring-2009/related-resources/drawing_and_sketching/

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

CO1	Understand and apply the concepts of lettering and dimensioning for drafting of machine drawings and building drawings and different Conics and Engineering Curves.
CO2	Recognize and be familiar with the Orthographic projections of points, lines.
CO3	Develop the concept of Orthographic projections of planes and solids.
CO4	Differentiate between isometric scale, isometric projections and views.
CO5	Have a broad overview of various sheet-metal work by the concept of development of surfaces and solids and Sectional Views of Simple and compound solids.
CO6	Draw various machine components and building structure drawing by using AutoCAD.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	1	1					2	1	1	1	1	1
CO2	3	2	1	1	1					2	1	1	1		1
CO3	3	2	1	1	1					2	1	1	1		1
CO4	3	1	1	1	1					2	1	1	1		1
CO5	3	2	2	2	3					2	2	1	1		1
CO6	3	2	1	1	2					2	2	1	1		1

Type	Code	Basic Electronics Engineering Lab	L-T-P	Credits	Marks
ES	18ES1L01		0-0-2	1	100

Objectives	Know broadly the concepts and functionalities of the electronic devices, tools and instruments. Understand general specifications and deployability of the electronic devices, and assemblies. Develop confidence in handling and usage of electronic devices, tools and instruments in engineering applications.
Pre-Requisites	Knowledge on intrinsic and extrinsic Semiconductors, Physics and Chemistry of Higher Secondary Science level.
Teaching Scheme	Regular laboratory experiments to be conducted under the supervision of teachers and demonstrators with the help of ICT, as and when required along with pre-lab session and demonstration for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Familiarization of electronic components and devices (Testing of semiconductor diodes and transistors using digital multi-meter).
2	Study and use of Oscilloscope, signal generator to view waveforms and measure amplitude and frequency of a given waveform.
3	V-I characteristics of semiconductor diode and determining its DC and AC resistances.
4	Implementation of clipper circuits, both positive clipper and negative clipper. Observe its output waveforms and compare them with theoretical analyzed results.
5	Study of half-wave and full-wave rectifier circuits without and with capacitor filter; recording of the waveforms and measurement of average and rms values of the rectified output.
6	Study of static characteristics of BJT in CE configuration.
7	DC biasing (Fixed bias) of the transistor in CE configuration and determination of its operating point.
8	Studies on Op-Amp applications (Inverting, non-inverting, integrating differentiating configurations) recording of the input-output waveforms.
9	Studies on logic gates (truth table verification of various gates, implementation of EXNOR and Half Adder using basic gates).
10	Design of 2:1 MUX and simple SR Latch.

Text Books:

T1. R. L. Boylestad and L. Nashelsky, ***Electronic Devices and Circuit Theory***, 11th Edition, Pearson Education.
T2. A. S. Sedra and K. C. Smith, ***Microelectronic Circuits***, 7th Edition, Oxford University Press.

Reference Books:

R1. V. K. Mehta and R. Mehta, ***Principles of Electronics***, 3rd Edition, S. Chand Publishing, 1980.

Online Resources:

1. http://vlab.co.in/ba_labs_all.php?id=1
2. http://iitg.vlab.co.in/?sub=59&brch=165

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

CO1	Familiarize with various electronic components, measuring instruments, semiconductor diodes and their applications.
CO2	Acquire knowledge of characteristics of transistors and design, testing & implementation of transistors in various applications
CO3	Gain understanding of operational amplifiers (Op-Amp) and design & testing of electronic circuits for various applications using Op-Amp.
CO4	Develop understanding of digital logic gates and design & test digital circuits for various applications using logic gates.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1										2		
CO2	3	3	2	1									3		
CO3	2	2	2	1									2		
CO4	2	2	3										2		

Type	Code	Basic Electrical Engineering Lab	L-T-P	Credits	Marks
ES	18ES1L02		0-0-2	1	100

Objectives	Introduce the students to different electrical components and basic safety rules and regulations, give hands on practice about different measuring and protection equipment and their operations, help the students to understand and verify the basic concept of electrical & magnetic circuits and electric machines. The laboratory experiments shall go hand-in-hand with the topics taught in the theory class.
Pre-Requisites	Basic knowledge of different electrical components and different analysis techniques of electrical and magnetic circuits. Topics taught in Basic Electrical Engineering theory class are essential to conduct the experiments.
Teaching Scheme	Regular laboratory experiments conducted under supervision of the teacher. Demonstration will be given for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Connection and measurement of power consumption of a fluorescent lamp.
2	Identification of different terminals of a DC compound machine.
3	Power and power factor measurement of 3-phase load by two wattmeter method.
4	Connection and testing of a single-phase energy meter.
5	Determination of open circuit characteristics (OCC) of DC shunt generator.
6	Calculation of power and power factor in series R-L-C circuit by AVW method.
7	Polarity test of a single-phase transformer.
8	Study of single-phase induction motors / fan motor.
9	Verify Thevenin's Theorem and Superposition Theorem.
10	Draw the B-H curve of a magnetic Specimen.
11	Starting of three-phase induction motor.
12	Regulation and efficiency of single phase transformer by direct loading.

Text Books:

T1. A. Husain, ***Fundamentals of Electrical Engineering***, 4th Edition, Dhanpat Rai & Co., 2016.
T2. B. L. Thereja & A. K. Thereja, ***A Textbook of Electrical Technology***, 23rd Edition, S. Chand & Co.

Reference Books:

R1. J. B. Gupta, ***A Textbook of Electrical Science***, S. K. Kataria & Sons, 2013.
R2. B. R. Gupta and V. Singhal, ***Electrical Science***, S. Chand & Co, 2005.

Online Resources:

1. www.nptel.iitm.ac.in/electricalengineering
2. www.electronics-tutorials.ws/dc-circuits

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

CO1	Get an exposure to common electrical components and their ratings.
CO2	Make electrical connections by wires of appropriate ratings.
CO3	Understand the usage of common electrical measuring instruments.
CO4	Understand the basic characteristics of transformers and electrical machines.
CO5	Verify different network theorems and magnetic properties.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1			2		1		1	1	1	1	1	1		1
CO2	2			2		1		2	1	1	2	1	1		1
CO3	1			3		2		2	1	1	1	1	1		1
CO4	1			2		2		1	1	2	2	1	1		1
CO5	1			1		1		1	1	1	1	1	1		1

Type	Code	Computer Programming Lab	L-T-P	Credits	Marks
ES	18ES1L03		0-0-4	2	100

Objectives	To enable the students to analyse problems, formulate and implement solutions using the C programming language. The students will develop logical understanding for converting solutions of problems into C programs to be executed on a computer.
Pre-Requisites	Basic analytical and logical understanding including basic knowledge and usage of computers is required for this course.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Introduction to computers and Linux operating system.
2, 3	Get acquainted with the programming environment - Linux commands and VI-editor.
4	Editing, compiling, executing, and debugging of simple C programs.
5	Programs using operators and formatted input/output statements.
6	Decision making using `if`, `if-else`, `else-if` ladder, nested `if`.
7	Decision making using `switch-case` construct.
8, 9	Loop control structure (`while`, `do-while`, `for`) with jump statements.
10	Nested loops (printing various formats)
11, 12	1-D arrays including operation like searching, sorting, merging etc.
13	Handling 2-D arrays such as matrix operations.
14, 15	Programs on strings using various string handling functions (library functions)
16, 17	Designing user-defined functions.
18, 19	Programs on recursion.
20	Designing user defined functions for string manipulation.
21	Passing arrays (both 1D and 2D) to functions.
22, 23	Structure, array of structure, nested structure.
24	Dynamic memory management.
25	Self-referential structure (create and display operation of single linked list)
26, 27	File handling - reading from and writing to files.
28	Command-line argument, pre-processor directives.

Text Books:

T1. E. Balagurusamy, ***Programming in ANSI C***, 7th Edition, McGraw-Hill Education, 2017.
T2. Y. Kanetker, ***Let Us C***, 16th Edition, BPB Publications, 2018.

Reference Books:

R1. B. W. Kernighan and D. M. Ritchie, ***The C Programming Language***, 2nd Edition, Pearson Education, 2015.
R2. H. Schildt, ***C: The Complete Reference***, 4th Edition, McGraw-Hill, 2017.
R3. A. Kelley and I. Pohl, ***A Book on C***, 4th Edition, Pearson Education, 2008.
R4. B. Gottfried, ***Schaum's Outline of Programming with C***, 3rd Edition, McGraw-Hill, 2017.

Online Resources:

1. https://www.w3resource.com/c-programming-exercises/
2. https://www.includehelp.com/c-programming-examples-solved-c-programs.aspx
3. https://www.onlinegdb.com/online_c_compiler
4. https://www.tutorialspoint.com/compile_c_online.php

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

CO1	Construct C programs for mathematical operations using control statements.
CO2	Develop C programs for Array and String manipulation.
CO3	Construct modular programs for better maintenance and reusability.
CO4	Manipulate heterogeneous data using structure and union.
CO5	Create and manipulate files using C programs.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1								1	3		2
CO2	3	3	3	2								1	3		2
CO3	3	3	3	2								1	3		2
CO4	3	2	2	2								1	2		1
CO5	3	3	2	3								1	2		2

Type	Code	Communicative & Technical English Lab	L-T-P	Credits	Marks
HS	18HS1L01		0-0-2	1	100

Objectives	This laboratory course is designed to make students effective communicators and addressing issues like speaking inhibitions, accomplished by individual and team activities based on the four skills of language (LSRW).
Pre-Requisites	Basic knowledge of English grammar and the ability to speak, read and write using the English language.
Teaching Scheme	Regular laboratory classes with various tasks designed to facilitate communication through pair work, group/team work, individual and group presentations, discussions, role plays, listening to audios, watching videos, business writing and vocabulary enhancement.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Ice-breaking activities: dealing with inhibitions to speak (team activity)
2	Just a Minute (individual activity)
3	Role Play on channels of communication in the business world (team activity)
4	Speech activity 1: content development (individual activity)
5	Speech activity 2: for fluency, delivery and appropriate body language (individual activity)
6	Ear training: developing pronunciation skills (individual activity)
7	Listening comprehension: listening for overall and specific information (individual activity)
8	Oral presentations: preparing for public speeches (team activity)
9	Reading comprehension 1 (individual activity)
10	Reading comprehension 2 (individual activity)
11	Group presentation (team activity)
12	Writing Activity 1 (individual activity)
13	Writing Activity 2 (individual activity)

Text Books:

T1. M. A. Rizvi, ***Effective Technical Communication***, 2nd Edition, Tata McGraw Hill, 2017.
T2. T. Balasubramaniam, ***English Phonetics for Indian Students***, Trinity Press.
T3. M. Raman and S. Sharma, ***Technical Communication: Principles and Practices***, Oxford University Press.

Reference Books:

R1. S. Samantray, ***Business Communication and Communicative English***, S. Chand & Co.
R2. J. Seeley, ***The Oxford Guide to Writing and Speaking***, Oxford University Press.
R3. B. K. Mitra, ***Communication Skills for Engineers***, Oxford University Press, 2011.
R4. B. K. Das, ***An Introduction to Professional English & Soft Skills***, Cambridge Univ. Press, 2009.

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

CO1	Speak in public and overcome their inhibitions to speak.
CO2	Communicate in simulated business contexts.
CO3	Develop English pronunciation skills through practice.
CO4	Work effectively as a member of a team or as a leader through group presentation assignments.
CO5	Critically analyse texts of various kind and compose effective business messages.

Program Outcomes Relevant to the Course:

PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1								1	1	3	1	3		3	3
CO2								1	3	3	2	3		2	2
CO3										3		3		2	2
CO4								2	3	3	2	3		3	3
CO5								1	1	3		3		2	3

Type	Code	Data Structures & Algorithms Lab	L-T-P	Credits	Marks
ES	18ES1L06		0-0-4	2	100

Objectives	Develop skills to design and analyze simple linear and non linear data structures. It strengthen the ability of students to identify and apply the suitable data structure for the given real world problem. It enables them to gain knowledge in practical applications of data structures.
Pre-Requisites	Knowledge of programming in C, specifically on structures, pointers, functions, recursion etc., are required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Operations on arrays – insert, delete, merge.
2	Selection Sort, Bubble sort.
3	Linear Search and Binary search.
4	Representation of sparse matrix.
5, 6	Addition and transpose of sparse matrix.
7	Implementation of stack using array.
8	Conversion of infix to postfix expression.
9	Evaluation of postfix expression.
10	Operations of queue using array.
11	Operations of circular queue.
12	Single linked list operations.
13	Single linked list operations (continued).
14	Double linked list operations.
15	Double linked list operations (continued).
16	Circular linked list operations.
17	Stack using linked list.
18	Queue using linked list.
19	Polynomial addition using linked-list.
20	BST operations.
21	BST operations (continued).
22, 23	Graph traversal (BFS, DFS).
24	Warshall's shortest path algorithm.
25	Insertion Sort, quick sort.

Cont'd...

Experiment-#	Assignment/Experiment
26	Merge Sort.
27, 28	Implementation of Heap Sort.

Text Books:

T1. E. Horowitz, S. Sahni, S. Anderson-Freed, ***Fundamentals of Data Structures in C***, 2nd Edition, Universities Press, 2008.
T2. M. A. Weiss, ***Data Structures and Algorithm Analysis in C***, 2nd Edition, Pearson Education, 2002.

Reference Books:

R1. A. K. Rath and A. K. Jagadev, ***Data Structures Using C***, 2nd Edition, Scitech Publication, 2011.
R2. Y. Kanetkar, ***Data Structures Through C***, 2nd Edition, BPB Publication, 2003.

Online Resources:

1. http://nptel.ac.in/courses/106102064/1
2. http://www.nptelvideos.in/2012/11/programming-and-data-structure.html
3. https://www.tutorialspoint.com/data_structures_algorithms/index.htm
4. https://www.coursera.org/learn/data-structures/
5. https://www.geeksforgeeks.org/data-structures/

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

CO1	Implement various operations on array and sparse matrix.
CO2	Design functions to implement basic operations on stack & queue and apply them to solve real world problems.
CO3	Implement single, double & circular linked list and apply them in various real life applications.
CO4	Construct binary search tree and perform traversal, insertion, deletion, and search operations on it.
CO5	Perform BFS and DFS traversal operations in a graph and implement various sorting and searching algorithms.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	2		1						1	3		3
CO2	3	3	3	2		1						1	3		3
CO3	3	3	3	2		1						1	3		3
CO4	3	3	2	3		2						1	3		3
CO5	3	3	3	3		1						1	3		3

Part II

2nd Year B. Tech. (CSE)

Curriculum Structure

Semester III									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
BS	18BS1T07	Math-III for CSE	3	0	0	3	0	0
ES	18ES1T07	Digital Electronics	3	0	0	3	0	0
PC	18BS1T09	Discrete Mathematics	3	1	0	3	1	0
PC	18ES1T06	OOP Using Java	3	0	0	3	0	0
ES	18ES1T08	Basics of Mechanical Engineering	3	1	0	3	1	0
HS	18HS1T02	Engineering Economics	3	0	0	3	0	0
PRACTICAL									
ES	18ES1L08	Digital Electronics Lab	0	0	2	0	0	1
PC	18ES1L07	OOP Using Java Lab	0	0	2	0	0	1
PJ	18IR6L01	Summer Internship - I	0	0	0	0	0	1
MC	18NC7L01	Yoga	0	0	2	0	0	0
		SUB-TOTAL	**18**	**2**	**6**	**18**	**2**	**3**
		TOTAL	**26**			**23**		

Semester IV									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
BS	18BS1T08	Math-IV for CSE	3	0	0	3	0	0
PC	18CS1T01	Design & Analysis of Algorithms	3	1	0	3	1	0
PC	18CS1T02	Database Management Systems	3	1	0	3	1	0
PC	18CS1T03	Computer Organization & Architecture	3	0	0	3	0	0
HS	18HS1T03	Fundamentals of Management	3	0	0	3	0	0
PRACTICAL									
PC	18CS1L01	Design & Analysis of Algorithms Lab	0	0	4	0	0	2
PC	18CS1L02	Database Management Systems Lab	0	0	4	0	0	2
PC	18CS1L03	Computer Organization & Architecture Lab	0	0	2	0	0	1
		SUB-TOTAL	**15**	**2**	**10**	**15**	**2**	**5**
		TOTAL	**27**			**22**		

Type	Code	Mathematics-III for CSE	L-T-P	Credits	Marks
BS	18BS1T07		3-0-0	3	100

Objectives	The objective of this course is to familiarize the CSE students with topics like calculus of functions of more than one variable, Fourier Series, Fourier Integral and Fourier Transform. Also the students will be introduced to stochastic processes to handle time-dependent probabilistic models.
Pre-Requisites	Knowledge of differential and integral calculus of one variable, coordinate geometry of two and three dimensions, matrix algebra and elementary probability theory is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Gradient, Double and Triple integration, Vector Calculus.	**8 Hours**
Module-2	Minima, Maxima and saddle points, test for positive definiteness of a matrix, singular value decomposition.	**8 Hours**
Module-3	Matrix Differentiation, Analysis of Variance.	**8 Hours**
Module-4	Stochastic Process and Markov chain.	**8 Hours**
Module-5	Periodic function and Fourier series, Euler formula, Even and odd functions, Half range expansions, Fourier integrals, Fourier cosine transform, Fourier since transform, Fourier transform.	**10 Hours**
	Total	**42 Hours**

Text Books:

T1. E. Kreyszig, ***Advanced Engineering Mathematics***, 8th Edition, Wiley India, 2015.
T2. G. Strang, ***Linear Algebra and Its Applications***, 4th Edition, Cengage Learning, 2015.
T3. R. E. Walpole and R. H. Myers, ***Probability and Statistics for Engineers and Scientists***, 8th Edition, Pearson Education, 2007.
T4. S. M. Ross, ***Introduction to Probability Models***, 9th Edition, Academic Press, 2006.
T5. K. B. Petersen and M. S. Pedersen, ***The Matrix Cookbook***, Technical University of Denmark (e-Book), 2012.

Reference Books:

R1. S. Pal and S. C. Bhunia, ***Engineering Mathematics***, 1st Edition, Oxford University Press, 2015.
R2. B. V. Ramana, ***Higher Engineering Mathematics***, 1st Edition, McGraw-Hill, 2017.

Online Resources:

1. https://nptel.ac.in/courses/111104075/
2. https://nptel.ac.in/courses/111104078/
3. https://nptel.ac.in/courses/111104092/
4. https://nptel.ac.in/courses/122104017/
5. https://nptel.ac.in/courses/122104017

6. https://nptel.ac.in/courses/111102111/
7. https://nptel.ac.in/courses/111105035/287
8. https://nptel.ac.in/courses/111105035/28
9. https://www.coursera.org/learn/differentiation-calculus
10. https://www.coursera.org/learn/single-variable-calculus
11. https://atmos.washington.edu/~dennis/MatrixCalculus.pdf

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

CO1	Understand the concepts of calculus of several variables and its application to maxima & minima.
CO2	Gain knowledge regarding singular value decomposition of a matrix and apply it to solve engineering problems.
CO3	Acquire skill of performing analysis of variance.
CO4	Understand the stochastic model and apply it to study real life problems.
CO5	Apply Fourier series and Fourier Transform of a given function appropriately.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	3	1								2	1	1
CO2	3	3	2	1	2								2	1	1
CO3	3	3	3	3	1								2	1	1
CO4	3	3	3	2	3								2	1	1
CO5	3	3	2	2	2								2	1	1

Type	Code	Digital Electronics	L-T-P	Credits	Marks
ES	18ES1T07		3-0-0	3	100

Objectives	The objective of this course is to introduce the concepts & techniques associated with digital electronic systems and their design & implementations using VLSI technology.
Pre-Requisites	Knowledge of Basic Electronics and fundamentals of Number Systems is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Number System and their Conversion, Arithmetic Operation using 1's and 2's compliments, Logic Gates, Universal Logic Gates, Realization using logic gates, Boolean Function Simplification and Combinational Logic Design: Review of Boolean Algebra and De Morgan's Theorem.	**9 Hours**
Module-2	SOP & POS forms, Canonical forms, Karnaugh maps up to 5 variables, Binary codes and Their application, Code Conversion; MSI devices like Half and Full Adders, Subtractors, Comparators, Multiplexers, De-Multiplexors, Encoder, Decoder.	**9 Hours**
Module-3	Sequential Logic Design: Flip flops - S-R, JK and Master-Slave JK FF, Edge triggered FF, Ripple and Synchronous counters, Mod-N Counters.	**9 Hours**
Module-4	Shift registers, Finite state machines, Mealy and Moore models; Logic Families and Semiconductor Memories: TTL NAND gate, Specifications, Noise margin, Propagation delay, Fan-in, Fan-out, Tristate TTL, ECL, CMOS families and their interfacing.	**8 Hours**
Module-5	VLSI Design flow: Design entry - Schematic, FSM & HDL, different modeling styles in VHDL, Data types and objects, Data flow, Behavioral and Structural Modeling, Synthesis and Simulation, VHDL constructs and codes for combinational and sequential circuits.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. M. M. Mano and M. D. Ciletti, ***Digital Design: With an Introduction to Verilog HDL***, 5th Edition, Pearson Education, 2013.
T2. L. K. John and C. H. Roth Jr., ***Digital System Design using VHDL***, 2nd Edition, Cengage Learning, 2012.

Reference Books:

R1. D. V. Hall, ***Digital Circuits and Systems***, International Student Edition, McGraw-Hill Education, 1989.
R2. A. A. Kumar, ***Fundamentals of Digital Circuits***, 3rd Edition, PHI Learning, 2014.
R3. R. P. Jain, ***Modern Digital Electronics***, 4th Edition, McGraw-Hill Education, 2009.

R4. W. H. Gothmann, ***Digital Electronics - An Introduction to Theory and Practice***, 2nd Edition, PHI Learning, 1982.

Online Resources:

1. https://nptel.ac.in/courses/117106086/
2. https://swayam.gov.in/course/1392-digital-circuits-and-systems
3. https://nptel.ac.in/courses/117103064/
4. https://nptel.ac.in/courses/117105080/3
5. http://www.allaboutcircuits.com

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

CO1	Become familiar with various number systems, codes and Boolean algebra.
CO2	Design and analyze combinational logic circuits.
CO3	Design & analyze various sequential logic circuits and be familiar with counter design.
CO4	Design, analyze and implement memory array and investigate performance of CMOS based logic circuits applicable to modern VLSI technology.
CO5	Simulate and synthesize various digital circuits using VHDL in industry standard tool such as Xilinx, Mentor Graphics etc.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	3	2	1							2	1	
CO2	2	3	2	3	3	1							3	1	
CO3	2	3	2	3	3	1							3	1	
CO4	2	3	2	3	2	1							2	1	
CO5	2	3	2	3	2	1							2	1	

Type	Code	Discrete Mathematics	L-T-P	Credits	Marks
PC	18BS1T09		3-1-0	4	100

Objectives	The objectives of this course is to gain mathematical maturity to handle logical & abstract processes, discrete structures including graph and some important counting techniques which are essential for students of CSE.
Pre-Requisites	Knowledge of Sets, basics of number systems, and matrix algebra is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Propositional Logic, Propositional Equivalences, Predicates and Quantifiers, Nested Quantifiers, Rules of Inference, Proof Strategies.	**10 Hours**
Module-2	Mathematical induction, basics of counting, Pigeonhole principle, Permutations and Combinations, Binomial coefficients, Generalized permutation and combinations; Recurrence Relations, Solving linear Recurrence Relations, Divide and Conquer algorithms, Generating functions, Inclusion and Exclusion with applications.	**11 Hours**
Module-3	Relations and their properties, N-ary Relations & their applications, Representing relations, Closure of relations, Equivalence relations, Partial ordering, Lattice & Boolean algebra.	**12 Hours**
Module-4	Introduction to Graphs, Graph terminology, Representation of graphs & graph isomorphism, Connectivity, Euler & Hamilton paths, Shortest-path problems, Planar graph & Graph coloring; Introduction to trees, Applications of trees, Spanning trees.	**11 Hours**
Module-5	Semigroup, Monoid, Groups, Subgroups, Cosets and Lagrange's theorem, Codes and group codes, Isomorphisms & Automorphisms, Homomorphism & Normal Subgroup, Rings, Integral Domains & Fields.	**12 Hours**
	Total	**56 Hours**

Text Books:

T1. K. H. Rosen, ***Discrete Mathematics and Its Applications***, 6th Edition, Tata McGraw-Hill, 2008.
T2. C. L. Liu, ***Elements of Discrete Mathematics***, 2nd Edition, Tata McGraw-Hill, 2008.

Reference Books:

R1. J. P. Tremblay and R. Manohar, ***Discrete Mathematical Structures with Applications to Computer Science***, 1st Edition, McGraw Hill Education, 2017.
R2. J. R. Mott, A. Kandel, and T. P. Baker, ***Discrete Mathematics for Computer Scientists and Mathematicians***, 2nd Edition, Pearson Education India, 2015.

Online Resources:

1. http://www.nptel.ac.in/courses/111105035
2. http://www.nptel.ac.in/courses/122104017

3. http://nptel.ac.in/courses/122102009
4. http://nptel.ac.in/courses/111107063
5. https://swayam.gov.in/course/1396-discrete-mathematics
6. https://www.coursera.org/learn/linearalgebra2
7. https://www.coursera.org/learn/differentiation-calculus
8. https://www.coursera.org/learn/single-variable-calculus
9. https://alison.com/courses/Algebra-Functions-Expressions-and-Equations

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

CO1	Understand and apply logic and logical inferences.
CO2	Gain knowledge regarding principle of inclusion & exclusion, generating function and recurrence relations.
CO3	Understand the concepts of relation, lattice and Boolean algebra.
CO4	Apply graph theory to real-life problems of computer science & engineering.
CO5	Define and differentiate the discrete structures like semigroup group, ring & field, and apply it to study group codes.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	3	1								2	1	1
CO2	3	3	2	1	2								2	1	1
CO3	3	3	3	3	1								2	1	1
CO4	3	3	3	2	3								3	1	1
CO5	3	3	2	2	2								3	1	1

Type	Code	OOP Using Java	L-T-P	Credits	Marks
ES	18ES1T06		3-0-0	3	100

Objectives	The objective of this course is to introduce the key concepts of object-oriented programming (OOP) using Java as the programming language.
Pre-Requisites	Basic analytical and logical understanding including basic knowledge and usage of computers is required for this course. Prior experience with a programming language will be beneficial.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Object oriented concepts: Object oriented systems development life cycle, Unified Modeling Language, UML class diagram, Use-case diagram; Java Overview: Java Virtual Machine, Java buzz words, Data types, Operators, Control statements, Class fundamentals, Objects, Methods, Constructors, Overloading, Access modifiers.	**9 Hours**
Module-2	Inheritance: Basics of Inheritance, using super and final keyword, method overriding, Abstract classes, defining and importing packages, access protection, interfaces; Exception handling: Exception fundamentals, types, understanding different keywords (try, catch, finally, throw, throws), User defined exception handling.	**8 Hours**
Module-3	Input/Output: Files, stream classes, reading console input; Threads: thread model, use of Thread class and Runnable interface, thread synchronization, multithreading, inter thread communication.	**8 Hours**
Module-4	String manipulation: Basics of String handling, String class, StringBuilder, StringBuffer, StringTokenizer. Applet basics and life cycle; Event Handling: delegation event model, event classes, sources, listeners, Adapter class.	**8 Hours**
Module-5	Introduction to GUI Programming: working with windows, frames, graphics, color, and font. AWT Control fundamentals. Swing overview; JavaFX overview; Java database connectivity: JDBC overview, creating and executing queries, dynamic queries.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. H. Schildt, ***Java: The Complete Reference***, 10th Edition, McGraw-Hill, 2017.
T2. Y. D. Liang, ***Introduction to Java Programming***, 9th Edition, Pearson Education, 2012.

Reference Books:

R1. B. Bates, K. Sierra, ***Head First Java***, 2nd Edition, O'Reilly Media, 2005.
R2. T. Budd, ***An Introduction to Object-Oriented Programming***, 3rd Edition, Pearson Education, 2009.
R3. I. Horton, ***Beginning Java***, 7th Edition, Wrox Publications, 2011.

Online Resources:

1. https://nptel.ac.in/courses/106105191/
2. https://docs.oracle.com/javase/tutorial/
3. http://www.javatpoint.com/java-tutorial
4. http://www.w3schools.in/java/
5. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-00-introduction-to-computer-science-and-programming-fall-2008/video-lectures/lecture-14/

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

CO1	Apply object oriented principles in software design process to develop Java programs for real life applications.
CO2	Employ inheritance and exception handling techniques for developing robust and reusable software.
CO3	Develop programs using stream classes for various I/O operations and design concurrent programs using threads to maximize the use of processing power.
CO4	Design applications for text processing using String class and develop user interactive applications using event handling.
CO5	Design database driven GUI applications using AWT, Swing and JDBC.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	1		1						2	3		3
CO2	3	2	2	1		1						2	3		3
CO3	3	1	2	2		1						2	3		3
CO4	3	2	3	1		1						2	3		3
CO5	3	2	3	1		1						2	3		3

Type	Code	Basics of Mechanical Engineering	L-T-P	Credits	Marks
ES	18ES1T08		3-1-0	4	100

Objectives	The objectives of this course are to provide an introductory treatment of Mechanical Engineering with working knowledge of engineering mechanics and concepts of thermodynamics to enable the students understand implications of mechanics and thermodynamics in their stream of engineering.
Pre-Requisites	Basic analytical and logical skills, a working knowledge of Physics and Mathematics including introductory calculus are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Basic concepts of Thermodynamics and Pure Substances**: Introduction, basic concepts and definitions - System, Control Volume, Surrounding, Boundaries, Types of Systems, Macroscopic and Microscopic approaches, Thermodynamic Equilibrium, State, Property, Process, Exact & Inexact Differentials, Point and Path functions, Cycle – Reversibility and Irreversibility, Zeroth Law of Thermodynamics as the basis for Temperature Measurement – Principles of Thermometry, Types of Thermometers, Constant Volume gas Thermometer; Definition of pure substance, p-v, T-v, T-s and h-s diagrams for water, Triple point and critical state, properties during change of phase, Dryness Fraction ,Property tables. Ideal Gas Law, Equations of State.	**12 Hours**
Module-2	**First and Second Laws of Thermodynamics**: Joule's Experiments – First law of Thermodynamics, PMM1, First law applied to a Closed System, Steady Flow Energy Equation (SFEE) with examples such as Nozzle, Diffuser, Throttling devices, Turbine and Compressor; Kelvin-Planck and Clausius Statements; Corollaries, PMM2, Carnot's principle, Carnot cycle and the Thermodynamic Temperature Scale, Clausius Inequality, Entropy, Principle of Entropy Increase; Heat Engine Cycle (Steam Power Plant) and Refrigeration Cycle, Calculation of COP.	**12 Hours**
Module-3	**Engineering Mechanics**: Basic concepts, System of Forces, Coplanar Concurrent Forces, Resultant-Moment of Forces and its Applications; Couples, Moment (about point and about axis), Varignon's theorem, Resultant of concurrent and non-concurrent coplanar forces, Static equilibrium, Free body diagram, Reactions; Basic concept of pulleys, Friction, Laws of Coulomb friction; Problems involving large and small contact surfaces (Ladder and Wedges.)	**12 Hours**

Cont'd...

Module-#	Topics	Hours
Module-4	**Center of Gravity & Moments of Inertia**: Centroid and Centre of Gravity, Centroid of simple figures from first principle, Centroid of composite sections; Centre of gravity and its implications; Theorems of Pappus and Guldinus, Area moment of inertia - Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Mass moment inertia of circular plate, Cylinder, Cone, Sphere, parallelepiped.	**8 Hours**
Module-5	**Kinematics of Rectilinear and Curvilinear Motion**: Differential equations of rectilinear motion, D' Alembert's Principle, Momentum and Impulse, Work & Energy, Conservation of energy, Impact; Normal and Tangential acceleration, Motion of a Projectile, Work and Energy in curvilinear motion.	**12 Hours**
	Total	**56 Hours**

Text Books:

T1. R. E. Sonntag, C. Borgnakke, and G. J. Van Wylen, ***Fundamentals of Thermodynamics***, 9th Edition. John Wiley & Sons, 2017.
T2. Y. A. Cengel and M. A. Boles, ***Thermodynamics – An Engineering Approach***, 8th Edition, McGraw-Hill, 2017.
T3. S. Timoshenko, D. H. Young, S. Pati, and J. V. Rao, ***Engineering Mechanics***, 5th Edition, McGraw-Hill, 2013.

Reference Books:

R1. P. K. Nag, ***Engineering Thermodynamics***, 4th Edition, McGraw-Hill, 2008.
R2. J. L. Meriam and L. G. Kraige, ***Engineering Mechanics: Statics*** & ***Engineering Mechanics: Dynamics*** (two books), 7th Edition, John Wiley & Sons. 2012.
R3. S. S. Bhavikatti, ***Engineering Mechanics***, 3rd Edition, New Age International, 2008.

Online Resources:

1. https://nptel.ac.in/courses/112103108/: Engineering Mechanics
2. https://nptel.ac.in/courses/112105123/: Basic Thermodynamics

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

CO1	Become familiar with the terms used in thermodynamics and measurement of temperature, pressure and pure substances.
CO2	Acquire skills and knowledge to apply the first law of Thermodynamic to solve the problems related to steady flow devices and understand the concepts of second law of Thermodynamics.
CO3	Understand the principles of mechanics and analyze static systems to solve real life problems.
CO4	Realize concepts of centroid, center of gravity and distributed forces in a plane, determine the area and mass moments of inertia and apply them for basic structural design.
CO5	Acquire skills and knowledge to solve problems in dynamics for both rectilinear and curvilinear motion.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.

Cont'd...

PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2	2	1								2		1
CO2	2	1	2	2	1								2		1
CO3	3	3	2	2	1								2		1
CO4	3	3	3	1	1								2		1
CO5	3	3	2	2	1								2		1

Type	Code	Engineering Economics	L-T-P	Credits	Marks
HS	18HS1T02		3-0-0	3	100

Objectives	The objective of this course is to familiarize the students with elementary principles of economics, provide the tools needed for analyzing time value of money in engineering decision making, profit/revenue data, and make economic analysis for projects and alternatives.
Pre-Requisites	Basic knowledge on interest formula and derivatives is required.
Teaching Scheme	Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with focus on real-world problem solving.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Engineering Economics-its meaning and importance, Basic problems of an economy. The concept of time value of money; Concept of Interest. Time value of equivalence, Compound interest factors; Cash flow diagrams, Calculation of time value of equivalence, Present worth comparison, Future worth comparison, Pay-back period comparison.	**9 Hours**
Module-2	Equivalent annual worth comparison method, Situations for equivalent annual worth comparison, Rate of return, Internal rate of return, Incremental IRR analysis, Depreciation analysis, Methods of depreciation, Straight line method, Declining balance method, SOYD Method and MACRS method of depreciation; After tax comparison, Analysis of public Project, Cost-benefit analysis.	**9 Hours**
Module-3	Introduction to Micro Economics and Macro Economics, Theory of demand, Elasticity of demand, Price elasticity of demand, Measurement of elasticity of demand; Income elasticity and cross elasticity of demand, Demand forecasting; Law of supply, Elasticity of supply.	**8 Hours**
Module-4	Theory of production, Law of variable proportion, Laws of returns to scale, Cost Concepts, Total Costs, Fixed cost, Variable cost, Revenue concepts, Total revenue, Average revenue and marginal revenue, Market (Forms of market), Perfect Competition, Determination of price under perfect competition, Linear Break-even Analysis.	**8 Hours**
Module-5	Inflation, Meaning of inflation, Types, Causes, Measures to control inflation, Commercial Banks, Functions of Commercial Bank, Central bank, Functions of central Bank; National income, Definitions, Concepts of national Income, Methods of measuring National Income.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. L. Riggs, D. D. Bedworth, and S. U. Randhawa, ***Engineering Economics***, 4th Edition, Tata McGraw-Hill, 2004.

T2. H. L. Ahuja, ***Principles of Micro Economics***, 16th Edition, S. Chand & Co, 2008.
T3. R. R. Paul, ***Monetary Economics***, 11th Edition, Kalyani Publishers, 2015.

Reference Books:

R1. C. S. Park, ***Contemporary Engineering Economics***, 6th Edition, Pearson Education, 2015.
R2. D. G. Newnan, T. G. Eschenbach, J. P. Lavelle, and N. A. Lewis, ***Engineering Economic Analysis***, 13th Edition, Oxford University Press, 2017.
R3. A. Koutsoyiannis, ***Modern Micro Economics***, 2nd Edition, Palgrave Macmillan UK, 2003.
R4. H. C. Petersen, W. C. Lewis, and S. K. Jain, ***Managerial Economics***, 4th Edition, Pearson, 2005.
R5. N. G. Mankiw, ***Macroeconomics***, 7th Edition, Worth Publishers, 2010.
R6. M. P. Agasty, ***Engineering Economics and Costing***, 2nd Edition, Scitech Publication, 2009.

Online Resources:

1. https://nptel.ac.in/courses/112107209/: Engineering Economic Analysis
2. https://www.icai.org/post.html?post_id=10058: Study Materials by ICAI
3. http://www.icaiknowledgegateway.org/littledms/folder1/chapter-5-part-2.pdf: National Income Accounting
4. http://www.m5zn.com/newuploads/2013/05/28/pdf/ed6f3d1f87b9cd2.pdf: eBook

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

CO1	Understand the concepts of economics, engineering economics and its application in engineering.
CO2	Solve problems related to engineering economics and analyze decision alternatives in engineering projects.
CO3	Evaluate how changes in demand and supply affect market and production.
CO4	Assess the effects of changes in costs, selling price and units sold on the break-even point and target profit.
CO5	Analyze the macroeconomic environment of the business and its impact on society and enterprise.

Program Outcomes Relevant to the Course:

PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						1			1		3	1		1	2
CO2						1			1		3	1		1	3
CO3						2	2				3	1		1	2
CO4						2	2		1		3	1		1	3
CO5						2	2		1		3			2	2

Type	Code	Digital Electronics Lab	L-T-P	Credits	Marks
ES	18ES1L08		0-0-2	1	100

Objectives	The objective of the course is to understand the internal structure of logic gates, its implementation using Boolean algebra, designing digital circuits like counters, registers and formulating digital systems using HDL.
Pre-Requisites	Knowledge of Basic Electronics is required.
Teaching Scheme	Regular laboratory experiments to be conducted under supervision of the faculty with use of ICT as and when required, with focus on implementation using hardware & software tools.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Digital Logic Gates: Investigate logic behavior of AND, OR, NAND, NOR, EX-OR,EX-NOR, Invert and Buffer gates, use of Universal NAND Gate.
2	Gate-level minimization: Two level and multilevel implementation of Boolean functions.
3	Combinational Circuits: design, assemble and test: adders and subtractors, Code Converters, gray code to binary and 7-segment display.
4	Design, implement and test a given design example with: (a) NAND Gates only, (b) NOR Gates only, and (c) Using minimum number of Gates.
5	Design with multiplexers and de-multiplexers.
6	Flip-Flop: assemble, test and investigate operation of SR, D & J-K flip-flops.
7	Shift Registers: Design and investigate the operation of all types of shift registers with parallel load.
8	Counters: Design, assemble and test various ripple and synchronous counters - decimal counter, Binary counter with parallel load.
9	Memory Unit: Investigate behaviour of RAM and its storage capacity – 16 $\times$ 4 RAM: testing, simulating and memory expansion.
10	Clock-pulse generator: design, implement and test.
11	Parallel adder and accumulator: design, implement and test.
12	Binary Multiplier: design and implement a circuit that multiplies 4-bit unsigned numbers to produce a 8-bit product.
13	Verilog/VHDL simulation and implementation of Experiments listed at #3 to #12.

Text Books:

T1. M. M. Mano and M. D. Ciletti, ***Digital Design: With an Introduction to Verilog HDL***, 5th Edition, Pearson Education, 2013.

Reference Books:

R1. A. M. Michelén, ***Digital Electronics Laboratory Manual***, Prentice Hall, 2000.

R2. J. W. Stewart, C. -Y. Wang, ***Digital Electronics Laboratory Experiments*** (Using the Xilinx XC95108 CPLD with Xilinx Foundation: Design and Simulation Software), Prentice Hall, 2001.

Online Resources:

1. https://www2.mvcc.edu/users/faculty/jfiore/Resources/DigitalElectronics1LaboratoryManual.pdf
2. https://www.elprocus.com/top-digital-electronic-projects-for-electronics-engineering-students/

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

CO1	Analyse the function of logic gates and implementation of Boolean functions.
CO2	Realize Universal gates and Implementation of minimized Boolean Expressions.
CO3	Design and analyze different combinational circuits.
CO4	Design various asynchronous and Synchronous Sequential Circuits.
CO5	Acquire knowledge about internal circuitry and logic behind any digital system.
CO6	Simulate various digital circuits using VHDL in industry standard tool such as Xilinx.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	3	2	1							2	1	
CO2	2	3	3	3	3	1							3	1	
CO3	2	3	3	3	3	1							3	1	
CO4	2	3	2	3	2	1							2	1	
CO5	2	3	2	3	2	1							2	1	
CO6	2	3	2	3	2	1							2	1	

Type	Code	OOP Using Java Lab	L-T-P	Credits	Marks
ES	18ES1L07		0-0-2	1	100

Objectives	The objective of the course is to apply object oriented programming principles and implement object oriented programming using JAVA language.
Pre-Requisites	Basic analytical and logical understanding including basic knowledge and usage of computers is required for this course. Prior experience with any other object oriented programming language will be beneficial.
Teaching Scheme	Regular laboratory classes with the use of ICT whenever required, demonstration through practical simulation of code using IDE.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Understanding Java platform, compilation, and execution of a java program.
2	Overview of Eclipse IDE.
3	Use of class, use of control statements, data types, operators.
4	Implement class, object, constructor, methods, and other OOP features.
5	Inheritance Basics, more uses of constructor, method overriding, use of final.
6	Object class, practical use of abstract class.
7	Using Interface for achieving multiple inheritance, implementation of package.
8	Exception handing fundamentals, java built-in exceptions, Use of Scanner class for console input, use of own Exception subclass.
9	Java thread life cycle model and implementation approach, thread priority, implementation of synchronization.
10	I/O Basics, byte stream and character streams, reading and writing files.
11	Applet life cycle implementation, text processing using Java predefined String, StringBuilder and StringBuffer classes.
12	GUI basics and Window fundamentals, working with different Component, Container and Layout Managers.
13	Event handling for interactive GUI application.
14	Java database connectivity using JDBC, steps and use of different drive types.

Text Books:

T1. H. Schildt, ***Java: The Complete Reference***, 9th Edition, McGraw-Hill, 2011.
T2. Y. D. Liang, ***Introduction to Java Programming***, 9th Edition, Pearson Education, 2012.

Reference Books:

R1. B. Bates, K. Sierra, ***Head First Java***, 2nd Edition, O'Reilly Media, 2005.
R2. T. Budd, ***An Introduction to Object-Oriented Programming***, 3rd Edition, Pearson Education, 2009.
R3. I. Horton, ***Beginning Java***, 7th Edition, Wrox Publications, 2011.

Online Resources:

1. https://nptel.ac.in/courses/106105191/
2. https://docs.oracle.com/javase/tutorial/
3. http://www.javatpoint.com/java-tutorial
4. http://www.w3schools.in/java/
5. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-00-introduction-to-computer-science-and-programming-fall-2008/video-lectures/lecture-14/

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

CO1	Apply object oriented principles in software design process and develop Java programs for real-life applications.
CO2	Employ inheritance and exception handling techniques for developing robust, reusable software.
CO3	Develop programs using stream classes for various I/O operations and design concurrent programs using threads to maximize the use of processing power.
CO4	Design applications for text processing using String class and develop user interactive applications using event handling.
CO5	Design database driven GUI applications using AWT, Swing and JDBC.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	1		1						2	3		3
CO2	3	2	2	1		1						2	3		3
CO3	3	1	2	2		1						2	3		3
CO4	3	2	3	1		1						2	3		3
CO5	3	2	3	1		1						2	3		3

Type	Code	Yoga	L-T-P	Credits	Marks
MC	18NC7L01		0-0-2	0	100

Objectives	To impart skills in students for control of mind, body and soul, enhance self-awareness, focus, and concentration, bring together physical and mental wellness, manage stress and anxiety, achieve perfect equilibrium and harmony of body & mind, and promote self-healing.
Pre-Requisites	There are no pre-requisites for this course.
Teaching Scheme	Regular practice classes conducted under supervision of the qualified Yoga teacher with necessary explanation and demonstration for each session.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Introduction; introduction of Yoga
2	*Pranayama*; performing breathing exercise
3	*Mudra*; learning various types of *Mudra*s and their benefits
4	*Bandha*: learning various types of *Bandha*s and their benefits
5	*Chakra*; learning various types of *Chakra*s and their benefits
6	*Chakshu Visrant Asana Samuha*; eye movement and exercises
7	Twisting set; standing twisting asana
8	Side stretching set; standing Side stretching *asana*
9	Forward bending set; standing Forward bending *asana*
10	Backward bending set; standing Backward bending *asana*
11	Balancing set; learning *Vrikshasana*, *Ekpada Pranamasana* and benefits
12	*Surya Namaskar*; surya namaskar mantra and poses
13	*Vajrasana* set; sitting *asana* sets
14	*Padmasana* set; sitting *asana* sets
15	Sleeping asana and *Yoga Nidra*; relaxation postures

Text Books:

T1. E. F. Bryant, ***The Yoga Sutras of Patanjali***, 1st Edition, North Point Press, 2009.

Reference Books:

R1. Swami Satyananda Saraswati, ***Asana Pranayama Mudra Bandha***, 4th Edition, Yoga Publication Trust, Munger (Bihar), India, 2008.

Online Resources: *There are a number of online resources available for this course. The student is advised to search on the Internet and locate the required study materials as per advise of the teacher.*

P.T.O

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

CO1	Promote positive health, get relief from stress and obtain balance of body & mind.
CO2	Acquire knowledge of integral approach of Yoga Therapy to common ailments.
CO3	Develop skills to adopt Yoga practices for health and general well-being.
CO4	Develop overall personality through control of body, mind and soul.
CO5	Enhance scientific attitude and team spirit for creative and constructive endeavors.

Program Outcomes Relevant to the Course:

PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						1		1	3			2		1	2
CO2						1			1			2		1	2
CO3						2			1			2		1	2
CO4								2	3			1		2	3
CO5						2		2	2			1		2	3

Type	Code	Mathematics-IV for CSE	L-T-P	Credits	Marks
BS	18BS1T08		3-0-0	3	100

Objectives	The objective of this course is to provide a good exposure to linear and non-linear programming with several standard numerical methods, and the right kind of tools to solve large scale optimization problems in engineering.
Pre-Requisites	Knowledge of calculus of several variables, coordinate geometry of two and three dimensions and matrix algebra is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Linear Programming: Graphical Method, Simplex Method, Big-M Method, Alternate optima, redundancy & degeneracy.	**8 Hours**
Module-2	Simplex Method Algorithm, Revised Simplex Method, Dual Problem, Construction of Dual, Duality Theorem (without proof), Dual Simplex method, Post Optimal analysis.	**9 Hours**
Module-3	Integer Linear Programming: Gomory's cutting Plane Method for different IPP, Branch & Bound Method, Convex Function, Convex Programming Problem.	**8 Hours**
Module-4	Quadratic Programming, Wolfe's method for QPP, Optimality Conditions, Lagrangian & Lagrange Multipliers, KKT Necessary/sufficient optimality conditions, duality in non-linear programming; Unconstrained optimization: Line search methods for uni-modal functions, the Steepest Descent method, Newton's method.	**11 Hours**
Module-5	Constrained Optimization: Frank Wolfe's Method, Rosen's Gradient Projection Method, Penalty function method.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Chandra, Jayadeva, and A. Mehera, ***Numerical Optimization with Applications***, 1st Edition, Narosa Publishing House, 2013.

Reference Books:

R1. D. G. Luenberger and Y. Ye, ***Linear & Nonlinear Programming***, 3rd Edition, Springer, 2008.
R2. S. S. Rao, ***Engineering Optimization***, 4th Edition, New Age Publishers, 2009.
R3. K. Dev, ***Optimization for Engineering Design***, 2nd Edition, Prentice Hall India, 2012.

Online Resources:

1. https://nptel.ac.in/courses/106108056/
2. https://nptel.ac.in/courses/111105100/

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

CO1	Solve linear programming problems using graphical and simplex methods.
CO2	Understand the concept of duality in linear programming and apply the same to solve problems and to perform post optimal analysis.
CO3	Solve integer programming and quadratic programming problems.
CO4	Understand the concepts and conditions to solve a non-linear programming problem and able to solve unconstrained optimization problems.
CO5	Solve constrained optimization problems and understand the Karmakar's Algorithm.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	3	1								2	1	1
CO2	3	3	2	1	2								2	1	1
CO3	3	3	3	3	1								2	1	1
CO4	3	3	3	2	3								2	1	1
CO5	3	3	2	2	2								2	1	1

Type	Code	Design & Analysis of Algorithms	L-T-P	Credits	Marks
PC	18CS1T01		3-1-0	4	100

Objectives	The objectives of this course is to introduce the classic algorithms in various domains, techniques for designing efficient algorithms, apply the algorithm design techniques to solve problems, and analyze the complexities of various problems in different domains.
Pre-Requisites	Knowledge of Discrete Mathematics and Data Structures is essential.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction, Definition, Characteristics of algorithm, Growth of Functions, Asymptotic analysis, Standard notations & common functions, Recurrences, Solution of recurrences by iterative, recursion tree, substitution and Master method; Algorithm design techniques, Divide & conquer strategy for designing algorithms, Obtaining best, average, worst-case running time of Merge sort, Quick sort & Randomized Quick sort with proofs.	**12 Hours**
Module-2	Heaps, Building a Heap, The heap sort algorithm, Priority Queue with their analysis; Lower bounds of sorting; Dynamic Programming, Elements of dynamic programming, Matrix chain multiplication, Longest Common Subsequence, String matching algorithms (Naive, Rabin-Karp, Knuth-Morris-Pratt algorithm).	**10 Hours**
Module-3	Greedy algorithms, Elements of Greedy strategy, Activity selection problem, Fractional Knapsack problem along with correctness proofs, Huffman codes; Backtracking and Branch & Bound techniques (n-Queen, Knapsack, Bin packing and Travelling Salesman problem); Data structure for disjoint sets, Disjoint set operations, Linked list representation, Path compression, Disjoint set forest, Obtaining running time of above algorithms with proofs.	**12 Hours**
Module-4	Graph algorithms and their characteristics, Breadth-first and depth-first search, Minimum spanning trees, Kruskal and Prim's algorithms, Single-source shortest path algorithms (Bellman-Ford, Dijkstra), All-pair shortest path algorithm (Floyd-Warshall) with their analysis; Maximum flow problem, Ford-Fulkerson algorithm and its analysis.	**10 Hours**
Module-5	NP completeness (Polynomial time, Polynomial time verification, NP completeness and reducibility), Cook's Theorem (without proof), Examples of NP complete problems (without proof) - Circuit satisfiability, 3-CNF satisfiability, Clique, Vertex cover, Ham-cycle, TSP (without proof); Approximation algorithm characteristics, Travelling Salesman Problem, Randomized algorithms (Max3-CNF satisfiability, PSPACE: A class of problems beyond NP.	**12 Hours**
	Total	**56 Hours**

Text Books:

T1. T. H.Cormen, C.E.Leiserson, R. L.Rivest, and C. Stein, ***Introduction to Algorithms***, 3rd Edition, PHI Learning, 2014.
T2. E. Horowitz, S.Sahni, and S.Rajasekaran, ***Fundamentals of Computer Algorithms***, 2nd Edition, University Press, 2015.
T3. J. Kleinberg and E. Tardos, ***Algorithm Design***, 1st Edition, Pearson Education, 2013.

Reference Books:

R1. M. T. Goodrich and R. Tamassia, ***Algorithm Design: Foundations, Analysis, and Internet Examples***, 1st Edition, John Wiley & Sons, 2001.
R2. U. Manber, ***Introduction to Algorithms: A Creative Approach***, 1st Edition, Addison-Wesley, 1989.
R3. S. Sridhar, ***Design and Analysis of Algorithms***, 1st Edition, Oxford University Press, 2014.
R4. G. Sharma, ***Design & Analysis of Algorithms***, 4th Edition, Khanna Publishers, 2019.

Online Resources:

1. http://www.nptelvideos.in/2012/11/design-analysis-of-algorithms.html
2. http://openclassroom.stanford.edu/MainFolder/CoursePage.php?course=IntroToAlgorithms
3. https://www.geeksforgeeks.org/fundamentals-of-algorithms/
4. https://www.tutorialspoint.com/design_and_analysis_of_algorithms/

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

CO1	Design algorithms, analyze their running time for best, worst, and average-cases, and understand divide & conquer strategy considering quick sort and merge sort as examples.
CO2	Compare Heapsort with other comparison based sorting algorithms, develop dynamic programming algorithms, and compare various pattern matching algorithms.
CO3	Apply disjoint-set data structure and various algorithm design techniques such as greedy, backtracking, and branch-and-bound in real life problems.
CO4	Model a given engineering problem using graphs and design the corresponding algorithms to solve the problem.
CO5	Understand NP complete problems, and design approximation and randomized algorithms for some of these problems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Cont'd...

PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	2	2							2	3		3
CO2	3	2	3	3	2	1						1	3		3
CO3	3	3	3	3	2	1						1	3		3
CO4	3	2	3	3	2	1						1	3		1
CO5	2	2	2	3	2	1						2	2		2

Type	Code	Database Management Systems	L-T-P	Credits	Marks
PC	18CS1T02		3-1-0	4	100

Objectives	The objective of the course is to understand the different aspects involved in the design, implementation, and operation of relational database systems, learn & use data manipulation language, explore the details of transaction processing, concurrency control, recovery, and get elementary knowledge on some advanced database concepts.
Pre-Requisites	Basic knowledge of data structures and algorithms is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to database systems: Basic concepts and definitions, three-schema architecture, data independence, Concept of data models, types of data models, database languages, integrity, database users, Entity-Relationship model, Constraints & Keys, Extended Entity Relationship model, Relational model, Mapping of E-R model to relational schema, System structure of DBMS, Codd's 12 Rules.	**11 Hours**
Module-2	Query languages: Relational Algebra, basic operations, join operations, grouping & aggregation, Tuple Relational Calculus, Domain Relational Calculus, Query-By-Example, Structured Query Language (SQL).	**9 Hours**
Module-3	Database design: Functional dependencies, Armstrong axioms, Attribute closure, Equivalence sets of FD, Minimal cover; Normalization: Dependency & attribute preservation, lossless join; Normal Forms: 1NF, 2NF, 3NF, BCNF, Testing for lossless design, Multi-Valued Dependency (MVD), 4NF and 5NF.	**10 Hours**
Module-4	Storage strategies: Storage Architecture, File and Record Organization, Types of Indexes, B-Tree, B+ Tree, Index Files, Hashing, Data Dictionary; Query processing and optimization: Evaluation of relational algebra expressions, Query optimization, Query cost estimation.	**8 Hours**
Module-5	Transaction processing: Basic concepts, ACID Properties, Serializability, Concurrency Control Schemes – lock-based & timestamp-based protocols, Deadlock handling, deadlock prevention, detection and recovery; Database Recovery: types of database failures, Recovery techniques - log-based recovery, checkpoints, shadow paging.	**10 Hours**
Module-6	Advanced Database Concepts: Distributed database, Homogeneous and heterogeneous distributed databases; Distributed data storage: data fragmentation & replication, data transparency, Distributed transactions; Parallel Databases: Introduction, Parallelism in Databases.	**8 Hours**
	Total	**56 Hours**

Text Books:

T1. A. Silberschatz, H. F. Korth, and S. Sudarshan, ***Database System Concepts***, 6th Edition, McGraw-Hill, 2013.
T2. R. Elmasri and S. B. Navathe, ***Fundamentals of Database Systems***, 7th Edition, Pearson Education, 2016.

Reference Books:

R1. R. Ramakrishnan and J. Gekhre, ***Database Management Systems***, 3rd Edition, McGraw-Hill, 2003.
R2. R. P. Mahapatra and G. Verma, ***Database Management Systems***, 1st Edition, Khanna Publishing, 2013.
R3. C. J. Date, ***Introduction to Database Systems***, 8th Edition, Pearson Education, 2003.

Online Resources:

1. https://nptel.ac.in/courses/106104135/
2. https://nptel.ac.in/courses/106105175/
3. https://cs145-fa18.github.io/
4. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-830-database-systems-fall-2010/lecture-notes/
5. https://docs.oracle.com/database/121/SQLRF/toc.htm

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

CO1	Understand the significance of database management system & its functional components and create E-R model for database design for real world application.
CO2	Construct queries using Relational Algebra, Relational Calculus, and perform database manipulation using structured query language.
CO3	Design relational databases based on real-world requirements and normalize the designs using different normalization techniques.
CO4	Get an insight to storage structures, various indexing techniques and access methods using those indexes, and devise optimal query execution strategies for efficient query processing.
CO5	Resolve currency control issues in transaction processing, and recover a database to its current state in case of failures.
CO6	Explore advanced database concepts such as distributed and parallel databases.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

Cont'd...

PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	1		2						1	2		1
CO2	3	3	3	2	1	1						1	2		1
CO3	3	3	3	2		1						2	1		1
CO4	2	2	2	2		1						1	1		1
CO5	2	3	3	2	1	2						1	2		2
CO6	2	2	1	1		1						1	1		1

Type	Code	Computer Organization & Architecture	L-T-P	Credits	Marks
PC	18CS1T03		3-0-0	3	100

Objectives	The objective of this course is to familiarize students about hardware design including logic design, basic structure and behaviour of the various functional modules of a modern digital computer and how they interact to provide the processing power to fulfil the needs of the user.
Pre-Requisites	Knowledge of basic digital electronics and computer fundamentals is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Basic structures of Computers: Computer Architecture vs. Computer Organization, Functional units, Operational concepts, Registers, Bus, Memory location and addresses, Big-endian and Little-endian representation, Instruction format, Instruction set Architecture, RISC Vs CISC, Addressing modes, Instruction Sequencing.	**9 Hours**
Module-2	Binary Arithmetic: Addition and subtraction of signed numbers, Design of Fast Adders, Multiplication of positive numbers, Signed Operand Multiplication, Fast multiplication, Integers Division, Floating – Point numbers representation, Floating – Point numbers operations.	**8 Hours**
Module-3	Basic Processing Units: Fundamental concepts, Execution cycle, Single Bus and Multi Bus Organization, Execution of complete instruction, Hardwired control, Micro programmed control, Basic concepts of pipelining, Pipeline hazards.	**8 Hours**
Module-4	Memory System: Basic Concepts, Semiconductor RAM memories, ROM, Speed, size and cost, Cache Memory concepts, Cache Memory mapping techniques, Performance consideration, Virtual Memory concepts, Translation Look-aside Buffer, Replacement techniques, Secondary Storage.	**9 Hours**
Module-5	Microprocessors, Instruction set, Assembly Language Programming, Stack, Subroutine, Accessing I/O devices, I/O mapped I/O, memory mapped I/O, Data transfer techniques, USB.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. C. Hamacher, Z. Vranesic, and S. Zaky, ***Computer Organization***, 5th Edition, McGraw-Hill, 2017.
T2. W. Stallings, ***Computer Organization and Architecture***, 9th Edition, Prentice Hall India, 2012.

Reference Books:

R1. M. M. Mano, ***Computer System Architecture***, 3rd Edition, Pearson Education, 2007.
R2. B. Govindarajalu, ***Computer Architecture and Organization***, 5th Edition, Tata McGraw-Hill, 2004.
R3. N. P. Carter, ***Schaum's Outline of Computer Architecture***, McGraw-Hill Education, 2002.

Online Resources:

1. https://nptel.ac.in/courses/106103068/
2. https://nptel.ac.in/courses/106103180/
3. https://nptel.ac.in/courses/117105078/
4. https://www.cse.iitk.ac.in/users/karkare/courses/2011/cs220/html/notes.html
5. https://homepage.cs.uiowa.edu/~ghosh/6012.html

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

CO1	Understand the architectural concepts of a digital computer, identify various functional units and describe their functionality, represent instructions in various formats, and solve problems based on addressing modes.
CO2	Perform various binary arithmetic operations using different techniques and represent floating point numbers & perform various operations on them.
CO3	Describe the working mechanism of the components of processing unit and discuss the techniques to enhance the performance of processing using pipelining.
CO4	Explain the working principle of Main memory, Cache memory and Virtual memory organization and solve numerical problems based on memory management.
CO5	Design assembly language programs for 8085/8086 microprocessors and differentiate among the techniques used for accessing I/O devices and standard I/O interfaces.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	3	2							1	2		3
CO2	3	3	2	3	1							1	2	1	2
CO3	3	3	3	2	2							1	2	1	2
CO4	2	3	3	2	1							1	3	2	3
CO5	2	3	3	2	1							1	1		1

Type	Code	Fundamentals of Management	L-T-P	Credits	Marks
HS	18HS1T03		3-0-0	3	100

Objectives	The objective of this course is to provide basic knowledge on management of business, finance, marketing, and human resources, which will help the students to grow from a team player to a good manager in an enterprise.
Pre-Requisites	General knowledge of any organization and its operations is sufficient.
Teaching Scheme	Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with real-life examples.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Concepts of Management**: Management as an art or science, the process of management, managerial skills, good managers are born, not made, management is concerned with ideas, things and people, inducing workers to put in their best, levels and types of management, evolution of management thought, managerial environment.	**8 Hours**
Module-2	**Functions of Management**: Planning and its features and process, types of plan, effective planning, Organizing and its process, formal and informal organization, directing and its elements, staffing and functions, controlling & its features and process, tools of controlling.	**6 Hours**
Module-3	**Marketing Function**: Modern concepts of marketing, marketing vs. selling, functional classification of marketing, functions of marketing management, marketing process; Marketing Mix: product and types of product, product life cycle, development of a new product, price, factors affecting price, pricing strategies; Distribution channel: role and functions, selection of a distribution channel, promotion and types of promotion, developing an advertising campaign, promotional strategies.	**12 Hours**
Module-4	**Financial Function**: Scope and objectives, financial functions, sources of finance, project appraisal, tools of financial decisions making, overview of working capital.	**6 Hours**
Module-5	**HRM Function**: Human Resource Management, Human Resource Development, importance of HRM, overview of job Analysis, job description, job specification, labour turnover; Manpower planning, recruitment, selection, induction, training and development, placement, wage and salary administration, performance appraisal, grievance handling, welfare aspects.	**10 Hours**
	Total	**42 Hours**

Text Books:

T1. S. A. Sherlekar and V. S. Sherlekar, ***Modern Business Organization & Management***, 4th Edition, Himalaya Publishing House, 2018.

Reference Books:

R1. C. R. Basu, ***Business Organization & Management***, 4th Edition, TMH, 2010.
R2. P. C. Tulsian and V. Pandey, ***Business Organization & Management***, 1st Edition, Pearson, 2002.
R3. P. Kotler, K. L. Keller, A. Koshy, and M Jha, ***Marketing Management***, 14th Edition, Pearson, 2012.
R4. I. M. Pandey, ***Financial Management***, 11th Edition, Vikas Publishing, 2015.
R5. K. Aswasthapa, ***Human Resource Management: Text and Cases***, 7th Edition, TMH, 2013.

Online Resources:

1. https://nptel.ac.in/courses/122108038/
2. https://iedunote.com/marketing-concept
3. https://www.tutorsonnet.com/functions-of-distribution-channel-homework-help.php
4. https://www.managementstudyhq.com/financial-function-types-importance-objectives.html

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

CO1	Describe the basic concepts of management and organization.
CO2	Explain fundamental management functions such as planning, directing, organizing, leading and controlling.
CO3	Adopt marketing policy by applying modern concept of marketing and select appropriate distribution channels.
CO4	Apply knowledge of financial functions in management for decision making.
CO5	Utilize the concepts of HRM functions to manage & develop human resources in an organization.

Program Outcomes Relevant to the Course:

PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						1	1		2		3	1		2	1
CO2									1		3	2		2	2
CO3						1	1		1		2	2		1	1
CO4											3	2		1	2
CO5						1	1		3		3	1		1	1

Type	Code	Design & Analysis of Algorithms Lab	L-T-P	Credits	Marks
PC	18CS1L01		0-0-4	2	100

Objectives	The objective of this course is to design and implement efficient algorithms for a specified application.
Pre-Requisites	Knowledge of Discrete Mathematics and Data Structures are essential.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Implementation of Linear & Binary Search.
2	Conversion of infix to postfix expression using Stack.
3	Binary Search Tree.
4	Sorting: Selection, Bubble and Insertion Sort.
5	Sorting: Quick Sort and Merge Sort.
6	Sorting: Implementation of Heap Sort.
7	Priority Queue using min-Heap.
8	Matrix Chain Multiplication.
9	Longest Common Subsequence.
10	Assembly-Line Scheduling.
11	Solve 0-1 Knapsack Problem.
12	Solve Activity Selection Problem.
13	Fractional Knapsack Problem.
14	Implementation of Huffman Code.
15	Solve n-Queen Problem
16, 17	Graph Traversal using BFS & DFS.
18	Kruskal's Algorithm for Minimum Spanning Tree.
19	Prim's Algorithm for Minimum Spanning Tree.
20	Bellman Ford's single source shortest path algorithm.
21	Dijkstra's Single source shortest path algorithm.
22	Warshall's all pair shortest path algorithm.
23	Ford-Fulkerson algorithm.
24	Rabin-Karp String matching algorithm.
25	Knuth-Morris-Pratt String matching algorithm.
26	Approximation algorithms for Travelling Salesman Problem.
27, 28	Mini Project.

Text Books:

T1. T. H.Cormen, C.E.Leiserson, R. L.Rivest, and C. Stein, ***Introduction to Algorithms***, 3rd Edition, PHI Learning, 2014.
T2. E. Horowitz, S.Sahni, and S.Rajasekaran, ***Fundamentals of Computer Algorithms***, 2nd Edition, University Press, 2015.

Reference Books:

R1. J. Kleinberg and E. Tardos, ***Algorithm Design***, 1st Edition, Pearson Education, 2013.
R2. M. T. Goodrich and R. Tamassia, ***Algorithm Design: Foundations, Analysis, and Internet Examples***, 1st Edition, John Wiley & Sons, 2001.
R3. U. Manber, ***Introduction to Algorithms: A Creative Approach***, 1st Edition, Addison-Wesley, 1989.

Online Resources:

1. http://www.nptelvideos.in/2012/11/design-analysis-of-algorithms.html
2. http://openclassroom.stanford.edu/MainFolder/CoursePage.php?course=IntroToAlgorithms
3. https://www.geeksforgeeks.org/fundamentals-of-algorithms/
4. https://www.tutorialspoint.com/design_and_analysis_of_algorithms/

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

CO1	Implement various searching and sorting algorithms and compare their execution time.
CO2	Understand and develop skill to solve problems using divide and conquer strategy.
CO3	Apply greedy, dynamic programming, backtracking and branch and bound paradigms to solve real life problems.
CO4	Formulate engineering problemsand solve them using graph algorithms.
CO5	Implement approximation algorithms to solve some of the NP-Complete problems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	2	1	1						2	3		3
CO2	3	2	3	3	1	2						1	3		2
CO3	3	3	3	3	1	3						1	3		3
CO4	3	3	3	3	1	3						1	3		3
CO5	2	2	2	3	1							2	3		2

Type	Code	Database Management Systems Lab	L-T-P	Credits	Marks
PC	18CS1L02		0-0-4	2	100

Objectives	The objective of this course is to provide a formal foundation in database design, query, and data manipulation, and impart hand-on practice to the students to groom them into well-informed database application developers.
Pre-Requisites	Knowledge of theory of databases and programming skills is required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Introduction to Oracle databases, simple queries for data retrieval.
2	Data retrieval based on conditions and sorting the query results.
3	Using single-row functions in SQL queries for data retrieval.
4	Applying grouping and aggregation functions.
5	Writing complex queries using sub-queries.
6	Create, alter, and manipulate design of tables.
7	Data manipulation using various DML statements.
8	Imposing various constraints on tables for maintaining data integrity.
9, 10	Retrieve data from multiple tables using various types of Join operations.
11	Create, alter, and manage Views from single & multiple base tables.
12	Create and use other data base objects like sequence, indexes, and synonyms.
13	Controlling user access to database using DCL queries.
14	Write SQL queries to perform set operations on tables.
14	Perform different advanced operations like rollup and cube.
16	Write SQL queries by using co-related sub-queries.
17	Introduction to PL/SQL, identifiers, literals, and keywords.
18	Write PL/SQL block by using conditional statements and expressions.
19	Using different types of Loops in a PL/SQL block.
20	Implement Exception Handling in a PL/SQL block.
21, 22	Write PL/SQL block by using numeric, string, and other miscellaneous data types.
23	Write PL/SQL block to retrieve data using cursors.
24	Introduction to Stored procedures, Write PL/SQL block using procedures.
25	Develop functions with in/out parameters and using them in a PL/SQL block.
26	Write PL/SQL block using package and trigger
27, 28	Develop a mini project

Text Books:

T1. K. Loney, ***Oracle Database 11g : The Complete Reference***, 1st Edition, McGraw-Hill, 2009.
T2. A. Silberschatz, H. F. Korth, and S. Sudarshan, ***Database System Concepts***, 6th Edition, McGraw-Hill, 2013.

Reference Books:

R1. I. Bayross, ***Teach Yourself SQL/PLSQL Using Oracle 8i and 9i with SQLJ***, 1st Edition, BPB Publications, 2003.
R2. S. Feuerstein, ***Oracle PL/SQL Programming***, 6th Edition, O'Reilly, 2014.

Online Resources:

1. https://nptel.ac.in/courses/106106095/pdf/4_The_SQL_Standard.pdf
2. https://docs.oracle.com/cd/B28359_01/appdev.111/b28370.pdf
3. https://www.javatpoint.com/oracle-tutorial

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

CO1	Construct queries using SQL and retrieve data from a database using single/multi-row functions, and sub-queries.
CO2	Design relational tables imposing integrity constraints, operate on and manipulate database tables using DDL/DML statements.
CO3	Create other database objects like views, sequences and indices.
CO4	Develop PL/SQL programs including control structures, loops, and exception handing on relational databases designed for real-world applications.
CO5	Implement advanced database techniques using Procedures, Functions, Parameters, Packages, and Triggers in PL/SQL.

Program Outcomes Relevant to the Course:

PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1		2		2	2							1	2		1
CO2		2		2	2							1	2		1
CO3			2	2	2							1	2		1
CO4		2		2	2							1	2		1
CO5		2		1	2							1	2		1

Type	Code	Computer Organization & Architecture Lab	L-T-P	Credits	Marks
PC	18CS1L03		0-0-2	1	100

Objectives	The objective of this course is to study the parts of computer and realize computer arithmetic & memory management operations through simulations.
Pre-Requisites	Knowledge of computer basics and programming logic is required.
Teaching Scheme	Regular Laboratory classes with the use of ICT whenever required through demonstration of various computer system components and simulation of some of the concepts using Assembly Language and SciLab.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Study of Computer Components
2	Study of Motherboard
3	Assembling and dissembling of a system
4	BIOS setting and installation
5	Introduction to 8085 Simulator and basic Assembly language programming
6	Assembly language programming in 8085 simulator using conditional statements
7	Assembly language programming in 8085 simulator using loop
8	Introduction to SciLab
9	SciLab Functions and Control Structures
10	Script files and Functions in SciLab
11	Implementation of basic logic gates and design of Adders
12	Simulation of Booth Algorithm and Integer division
13	Simulation of Pipelining
14	Simulation of Page Replacement Algorithms

Text Books:

T1. T. Sheth, ***SciLab : A Practical Introduction to Programming and Problem Solving***, 1st Edition, Create Space Independent Publishing Platform, 2016.
T2. S. Nagar, ***Introduction to Scilab For Engineers and Scientists***, 1st Edition, Apress, 2017.

Reference Books:

R1. S. L. Campbell, J. -P. Chancelier, and R. Nikoukhah, ***Modeling and Simulation in Scilab/Scicos with ScicosLab 4.4***, 1st Edition, Springer-Verlag, New York, 2006.
R2. H. Ramachandran and A. S. Nair, ***Scilab (A Free Software to MATLAB)***, 1st Edition, S. Chand & Co., 2011.

Online Resources:

1. https://www.scilab.org/tutorials
2. https://www.scilab.org/sites/default/files/Scilab_beginners_0.pdf
3. https://www.cse.iitb.ac.in/~cs626-449/scilab.pdf

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

CO1	Identify and analyze the components of digital computer and disassemble & assemble a modern digital computer.
CO2	Construct assembly programs using 8085 Simulator.
CO3	Analyze and Develop codes in SciLab using different control structures and functions.
CO4	Implement different logic gates for various binary arithmetic operations.
CO5	Implement different memory management techniques using SciLab.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	3							2	1		3
CO2	3	2	3	2	3							2	1	1	1
CO3	3	3	3	3	3							2	1	1	1
CO4	3	1	2	2	3							1	1	1	1
CO5	3	2	2	2	2							1	2	2	2

Part III

3rd Year B. Tech. (CSE)

Curriculum Structure

Semester V									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
PC	18CS1T04	Operating Systems	3	0	0	3	0	0
PC	18CS1T05	Computer Networks	3	1	0	3	1	0
PE	18**2T**	Professional Elective - I	3	0	0	3	0	0
PE	18**2T**	Professional Elective - II	3	0	0	3	0	0
BS	18BS1T11	Biology for Engineers	3	0	0	3	0	0
MC	18NC1T03	Professional Ethics & Values	2	0	0	0	0	0
PRACTICAL									
PC	18CS1L04	Operating Systems Lab	0	0	2	0	0	1
PC	18CS1L05	Computer Networks Lab	0	0	2	0	0	1
HS	18HS1L02	Soft Skills & Inter-Personal Skills Lab	0	0	4	0	0	2
PJ	18IR6L02	Summer Internship - II	0	0	0	0	0	1
		SUB-TOTAL	**17**	**1**	**8**	**15**	**1**	**5**
		TOTAL	**26**			**21**		

Semester VI									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
PC	18CS1T06	Software Engineering	3	0	0	3	0	0
PC	18CS1T07	Formal Languages & Automata Theory	3	0	0	3	0	0
PC	18CS1T08	Machine Learning	3	1	0	3	1	0
PE	18**2T**	Professional Elective - III	3	0	0	3	0	0
PE	18**2T**	Professional Elective - IV	3	0	0	3	0	0
PRACTICAL									
PC	18CS1L06	Software Engineering Lab	0	0	2	0	0	1
PC	18CS1L07	Formal Languages & Automata Theory Lab	0	0	2	0	0	1
PC	18CS1L10	Internet & Web Technology Lab	0	0	4	0	0	2
HS	18CS6L03	Skill Lab & Project - I	0	0	4	0	0	2
		SUB-TOTAL	**15**	**1**	**12**	**15**	**1**	**6**
		TOTAL	**28**			**22**		

Note: *Courses offered under each elective are given in "List of Electives" on Page 95.*

List of Electives

Code	Elective # and Subjects
	Professional Elective - I
18CS2T37	Data Mining & Data Warehousing
18CS2T24	Advanced Java Programming
18CS2T60	System Programming
	Professional Elective - II
18BS2T59	Statistical Inference
18CS2T49	Mobile Computing
18CS2T55	Realtime Systems
18CS2T61	Advanced Computer Architecture
	Professional Elective - III
18CS2T29	Artificial Intelligence
18CS2T62	Wireless Sensor Networks
18CS2T38	Distributed Databases
	Professional Elective - IV
18CS2T50	Natural Language Processing
18CS2T32	Cloud Computing
18CS2T52	Parallel & Distributed Systems

Type	Code	Operating Systems	L-T-P	Credits	Marks
PC	18CS1T04		3-0-0	3	100

Objectives	The objective of this course is to understand the fundamental concepts, techniques & algorithms, and internal working principles of a computer operating system to become a system designer or an efficient application developer.
Pre-Requisites	Knowledge of computer programming and data structures is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Overview, Evolution of operating system, Types of systems - Batch Processing, Multiprogramming, Time Sharing systems; Personal Computers, Parallel, Distributed, and Real-time Systems; Operating System Services, System components, System calls.	**6 Hours**
Module-2	**Process Management**: Process concepts, states, PCB, Process scheduling queues, queuing diagram, Types of schedulers, Operations on process; Inter-process communication - shared memory, message passing, Concept of buffering, Thread overview, Benefits of multi-threaded program, User and kernel threads, Multi-threading models, Issues with multi-threading - thread cancellation, thread pools, thread specific data; **CPU Scheduling**: Dispatcher, Scheduling - Criteria, Algorithms - FCFS, SJF, SRTF, RR, Priority, Multi-level Queue (MLQ), MLQ with Feedback.	**10 Hours**
Module-3	**Process Synchronization**: Background, Bounded-buffer – Shared-memory solution to Producer-consumer problem, Race condition, Critical section problem - Peterson's solution, Synchronization hardware: TestAndSet(), swap() instructions, Semaphores - Counting and binary semaphore, spinlocks, Classical problems of synchronization - Bounded-buffer problem, Readers-writers problem, Dining-philosophers problem, Monitors; **Deadlock**: System model, characterization, Resource-allocation graph, Methods for handling deadlocks, Deadlock prevention & avoidance, Banker's algorithm, Deadlock detection & recovery.	**10 Hours**
Module-4	**Memory Management**: Background, Logical & physical address space, Dynamic loading & dynamic linking, Swapping, Contiguous memory allocation, Dynamic storage allocation problem, Overlays, Paging, Segmentation; **Virtual Memory**: Background, Demand paging, Page fault, Basic page replacement policy, Page replacement algorithms - FIFO, OPT, LRU, LRU-Approximation, LFU, MFU, Thrashing, Working-set model.	**9 Hours**

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Module-#	Topics	Hours
Module-5	**Secondary Storage Structure**: Overview of mass storage structure, Disk structure, Disk scheduling - FCFS, SSTF, SCAN, C-SCAN, LOOK, C-LOOK, Swap-space management, RAID structure; File System: Concept, Access methods, Directory structure, Directory implementation, Allocation methods, Free space management, Access control list; I/O System: Polling, Interrupts, DMA; Case Studies: The LINUX System.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. A. Silberschatz, P. B. Galvin, and G. Gagne, ***Operating System Concepts***, 8th Edition, Wiley, 2009.
T2. M. Milenković, ***Operating Systems: Concepts and Design***, 2nd Edition, Tata McGraw-Hill, 2001.

Reference Books:

R1. A. S. Tanenbaum, ***Modern Operating Systems***, 3rd Edition, PHI, 2009.
R2. P. B. Prasad, ***Operating Systems and System Programming***, 2nd Edition, Scitech Publications, 2015.

Online Resources:

1. https://nptel.ac.in/courses/106/102/106102132/: by Prof. S. Bansal, IIT Delhi
2. https://nptel.ac.in/courses/106/108/106108101/: by Prof. P. C. P. Bhatt, IISc Bangalore
3. https://nptel.ac.in/courses/106/106/106106144/: by Prof. C. Rebeiro, IIT Madras
4. https://nptel.ac.in/courses/106/105/106105214/: by Prof. S. Chattopadhyay, IIT Kharagpur
5. https://www.cse.iitb.ac.in/~mythili/os/: Notes & slides by Prof. M. Vutukuru, IIT Bombay
6. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-828-operating-system-engineering-fall-2012/lecture-notes-and-readings/

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

CO1	Explore principles behind various types of operating systems, system components, system calls, protection mechanisms and services.
CO2	Explain different schedulers, scheduling policies, and design new scheduling algorithms for real life problems.
CO3	Describe the significance of process synchronization through classical synchronization problems and deadlock handling mechanisms.
CO4	Describe the working principle of main memory, cache memory and virtual memory organization and solve memory related problems.
CO5	Articulate secondary storage management, and analyze the performance of various disk scheduling algorithms.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Cont'd...

PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2									2	2	2	
CO2	3	3	3	2								2	3	3	1
CO3	3	3	3	2	1	1						2	3	3	1
CO4	3	3	3	2	1	1						1	3	3	1
CO5	2	2	3	2	1	1						1	3	3	1

Type	Code	Computer Networks	L-T-P	Credits	Marks
PC	18CS1T05		3-1-0	4	100

Objectives	The objective of this course is to study the fundamental concepts of computer networks and develop an understanding of modern network architectures from design & performance perspective.
Pre-Requisites	Basic knowledge of a computer system and Internet is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on real world examples.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Overview of Data Communication Networks, Protocols and standards, OSI Reference model, TCP/IP Protocol; Physical Layer: Analog Signals, Digital Signals, Data Rate Limits, Transmission Impairment, Transmission Modes; Digital Transmission: Digital-to-Digital & Analog-to-Digital conversion; Analog Transmission: Digital-to-Analog & Analog-to-Analog conversion; Multiplexing: FDM, TDM; Transmission Media: Guided Media, Unguided media; Switching: Circuit Switched, Datagram, and Virtual-Circuit Networks.	**12 Hours**
Module-2	**Error Detection & Correction**: Types of Errors, Error Detection mechanisms (Linear codes, Hamming codes, CRC, Checksum); **Data Link Control and Protocols**: Flow and Error Control, Stop-and-Wait ARQ, Go-Back-N ARQ, Selective Repeat ARQ; Introduction to HDLC and Point-to-Point Protocol; **Multiple Access Mechanisms**: Random Access - ALOHA, CSMA, CSMA/CD, CSMA/CA; Controlled Access: Polling, Reservation, Token Passing; Channelization: FDMA, TDMA, CDMA; **Wired LANs (Ethernet)**: Traditional, Fast, and Gigabit Ethernet.	**12 Hours**
Module-3	**Wireless LANs**: IEEE 802.11 Standards and Bluetooth; **Connecting Devices**: Hubs, Repeaters, Bridges, Switches, Routers, Gateway; **Network Layer**: IPV4 & IPV6 addresses, Subnets; **Internet Protocol**: Internetworking, IPV4 & IPV6 datagram format.	**12 Hours**
Module-4	**Network Layer Protocols**: ARP, RARP, ICMP; **Routing**: Unicast and Multicast Routing Protocols; **Transport Layer**: Process to Process Delivery, User Datagram Protocol (UDP) and Transmission Control Protocol (TCP), TCP and UDP segments and Flow Control.	**12 Hours**
Module-5	**Domain Name System (DNS)**: Name Space, Domain Name Space, DNS in Internet, Resolution and Dynamic Domain Name System (DDNS); Electronic Mail (SMTP) and File transfer Protocol (FTP); **World Wide Web (WWW)**: Architecture & Web document, HTTP: Persistent and Non-persistent Connection.	**8 Hours**
	Total	**56 Hours**

Text Books:

T1. B. A. Forouzan, ***Data Communication and Networking***, 4th Edition, Tata McGraw-Hill, 2014.
T2. A. S. Tannenbum and D. Wetherall, ***Computer Networks***, 5th Edition, Prentice Hall, Imprint of Pearson, 2016.

Reference Books:

R1. L. L. Peterson and B. S. Davie, ***Computer Networks: A System Approach***, 5th Edition, Elsevier, 2011.
R2. W. Stallings, ***Data and Computer Communications***, 10th Edition, Pearson Education, 2013.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105183/: by Prof. S. Chakraborty and Prof. S. K. Ghosh, IIT Kharagpur
2. https://nptel.ac.in/courses/106/106/106106091/: by Prof. H. A. Murthy, IIT Madras
3. https://nptel.ac.in/courses/106/105/106105080/: by Prof. A. Pal, IIT Kharagpur
4. https://nptel.ac.in/courses/106/105/106105081/: by Prof. S. Ghosh, IIT Kharagpur
5. http://intronetworks.cs.luc.edu/current/ComputerNetworks.pdf: eBook by Prof. P. L. Dordal, Loyola University, Chicago, USA

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

CO1	Describe the basics of computer networks, topology, TCP/IP, and OSI reference models.
CO2	Explain various techniques and modes of transmission (Analog and Digital).
CO3	Compare various Data Link protocols, Multi-Channel Access protocols and IEEE 802.xx standards for LAN.
CO4	Describe IPv4 & IPv6 addressing schemes, subnets, routing principles and algorithms used in the network layer.
CO5	Explain the protocols of transport & application layers and understand the working principles of Internet & the World Wide Web.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3								1	3	1	3
CO2	2	3	2	3								1	3	1	3
CO3	3	2	2	3								1	2	1	3
CO4	3	2	2	2		1						1	3	1	3
CO5	2	2	2	2		2						1	3	1	2

Type	Code	Data Mining & Data Warehousing	L-T-P	Credits	Marks
PE	18CS2T37		3-0-0	3	100

Objectives	The objective of this course is to understand the need for analysis of large, complex, information-rich data sets, study the fundamentals of data warehousing and discover useful information by data mining.
Pre-Requisites	Basic knowledge of database systems and probability theory is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Data Warehousing**: Introduction, Difference between operational databases and data warehouses, Three-tier architecture of Data Warehouse, Data Marts, Data staging area, Metadata.	**8 Hours**
Module-2	**Data Mining Basics**: Introduction, Application areas in data mining, KDD process; Getting to know your data: Data Objects and attributes types; Data Pre-processing: Why pre-process data? Data cleaning, Data integration, Data transformation and reduction.	**8 Hours**
Module-3	**Mining Frequent Patterns, Associations and Correlations**: Introduction, Market Basket Analysis, Frequent Item-set generation using Apriori algorithm, Rule generation; Alternative methods for generating frequent item-sets using FP-Growth algorithm, Evaluation of association patterns; From association analysis to correlation analysis.	**8 Hours**
Module-4	**Classification**: Introduction, Naïve Bayesian classifiers, Decision trees induction, Nearest neighbor classifiers; Neural Network: Multilayer perceptron model; Classification model evaluation techniques, Techniques to improve classification accuracy - Bagging, Boosting, Handling the class imbalance problem.	**10 Hours**
Module-5	**Clustering**: Overview, K-Means, K-Medoid, Agglomerative hierarchical clustering, DBSCAN, Cluster evaluation, Density-based clustering, Graph-based clustering, Scalable clustering algorithms.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Han, M. Kamber, and J. Pei, ***Data Mining: Concepts and Techniques***, 3rd Edition, Morgan Kaufmann, 2011.
T2. R. Thareja, ***Data Warehousing***, 1st Edition, Oxford University Press, 2009.

Reference Books:

R1. A. Berson and S. J. Smith, ***Data Warehousing, Data Mining & OLAP***, 1st Edition, McGraw Hill Education, 2017.
R2. P. N. Tan, M. Steinbach, A. Karpatne, and V. Kumar, ***Introduction to Data Mining***, 2nd Edition, Pearson Education, 2019.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105174/: by Prof. P. Mitra, IIT Kharagpur
2. http://infolab.stanford.edu/~ullman/mining/2003.html: notes by Stanford University

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

CO1	Describe the requirement of a data warehouse and its components.
CO2	Explain the concepts of data mining and data pre-processing.
CO3	Generate frequent patterns, association rules, and correlations using different data mining algorithms.
CO4	Analyze different classification algorithms and apply the same to real life problems.
CO5	Apply different clustering algorithms for solving problems in various domains.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1									1	3	1	1
CO2	3	3	1									1	3	1	1
CO3	3	3	2	1								1	3	1	1
CO4	3	3	2	1								1	3	1	1
CO5	3	3	2	1								1	3	1	1

Type	Code	Advanced Java Programming	L-T-P	Credits	Marks
PE	18CS2T24		3-0-0	3	100

Objectives	The objective of the course is to learn advanced features of the Java programming language, various frameworks in J2EE for rapid development, and apply these to develop enterprise applications.
Pre-Requisites	Knowledge of object oriented programming using Java is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on programming activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction to J2EE Environment**: Overview of J2EE and J2SE. J2EE Architecture JDBC: The Concept of JDBC, JDBC Driver Types, JDBC Packages, Database Connection, CRUD Operations using JDBC, Transaction Processing, Metadata; **Web Applications and Programming**: Web application architecture, Client, Server (Apache Tomcat/WebLogic), HTML5, CSS3; **Client Side Programming**: JavaScript, JQuery; Introduction to XML/JSON.	**9 Hours**
Module-2	**Servlets**: Introduction, Servlet Architecture, Environment Setup, Life Cycle, Form Data processing, Client HTTP Request, Server HTTP Response, HTTP Status Codes, Exception Handling; **Advanced Features of Servlets**: Handling Cookies, Session Tracking, URL rewriting, Database access, File uploading, Date handling, Page redirection, Sending email, Packaging, Debugging, Internationalization.	**8 Hours**
Module-3	**Java Server Pages (JSP)**: Advantages of JSP over Servlet, Lifecycle of a JSP page, JSP API, Scriptlet tag, Implicit objects, Directives, Exception handling, Action tags, Expression Language (EL); **Advanced Features of JSP**: Session Tracking, MVC, JSTL, Custom Tags, CRUD operations; **JSP Sample Code**: Pagination, Registration Form, File Uploading.	**8 Hours**
Module-4	**Enterprise JavaBeans (EJB)**: Introduction, Session Bean, JMS (Java Message Service), Message Driven Bean (MDB), Entity Bean; **Struts Framework**: Introduction, Features, Model 1 and Model 2 (MVC) Architecture, Interceptors, Struts 2 Architecture & Flow, Action, Configuration File, Validation, Ajax Validation, JSON Validation, Interceptor, Zero Configuration.	**8 Hours**
Module-5	**Java Mail API**: JavaMail Architecture, Sending emails, Sending email through Gmail Server, Receiving emails, Emails with HTML content, Forwarding, Deleting; **Hibernate Framework**: Introduction, Architecture, Web Application with Hibernate (using XML), Generator classes; **Spring Framework**: Introduction, Modules, Examples, Dependency Injection, AOP, JDBC Template.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Keogh, ***J2EE: The Complete Reference***, 11th Edition, McGraw Hill, 2017.
T2. Kogent Learning Solutions, ***Java Server Programming: Java EE 7 (J2EE 1.7) Black Book***, 1st Edition, DreamTech, 2014.

Reference Books:

R1. DT Editorial Services, ***J2EE 1.7 Projects Black Book***, 1st Edition, DreamTech, 2015.
R2. Kogent Learning Solutions, ***Web Technologies: HTML, Javascript, PHP, Java, JSP, XML and Ajax, Black Book***, 2nd Edition, DreamTech, 2009.

Online Resources:

1. https://www.tutorialspoint.com/ejb/index.htm
2. https://www.javatpoint.com/hibernate-tutorial
3. https://www.javatpoint.com/spring-tutorial
4. https://www.javatpoint.com/struts-2-tutorial

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

CO1	Explain concepts of J2EE and fundamentals of web application development.
CO2	Design web applications using JSP and Servlet technologies.
CO3	Design and develop complex enterprise applications using EJB frameworks.
CO4	Integrate email support in web applications using J2EE mail API.
CO5	Create enterprise J2EE application using Hibernate and Spring frameworks.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2									1	1		2
CO2	3	2	2		2							1	2	1	2
CO3	2	3	2		2							1	2	1	2
CO4	3	2	2	1	2							1	2	1	2
CO5	2	2	2	1	1							1	2	1	2

Type	Code	System Programming	L-T-P	Credits	Marks
PE	18CS2T60		3-0-0	3	100

Objectives	The objective of the course is to study the concepts & principles of system level programming and the methods & techniques for designing various system programs.
Pre-Requisites	Knowledge of computer programming and architecture is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on programming activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: System software and Application software; Operating System: Origin, Evolution, Types, OS as Resource Manager & Service Provider; **Machine Structure**: Stored program concept, Micro flowchart of ADD instruction, Machine structure – 360 and 370; **Machine Language**: Long way, No looping, Address modification, Looping with example, Introduction to assembly language program, Example using literals.	**9 Hours**
Module-2	**Assemblers**: Design of two pass assembler – Statement of problem, Data structure, Format of data bases, Algorithm and flowchart of Pass-I and II. Equivalent machine code generation of a sample assembly program; **Table Processing**: Linear and Binary search, Bubble sort – 360 assembly code and illustration, Radix sort, Shell sort, Address calculation sort, Radix exchange sort and Random entry searching.	**9 Hours**
Module-3	**Macro Processor**: Macro instruction arguments, Conditional macro expansion, Macro calls within macro, Macro instruction defining macro, Two pass algorithm for macro processor, Creation of MDT and MNT for Macro calls within macro and Macro instruction defining macro; **Programming Languages**: Importance of High Level Languages, Features, Data Types, Data Structures, Storage Allocation & Scope Names, Accessing Flexibility, Functional Modularity, Asynchronous Operations.	**8 Hours**
Module-4	**Loaders**: Function of a loader, Compile–and–go, General loader scheme, Absolute loader, Subroutine linkages, Relocating loaders, Other loader schemes – Dynamic loading & linking, Overlays, Bootstrap loader; Design of Absolute loader & Direct linking loader.	**8 Hours**
Module-5	**Compilers**: Phases – Lexical analysis, Syntax analysis, Semantic analysis, Intermediate code generation, Machine dependent & independent optimization, Storage assignment, Code generation, Assembly & Output; **Formal Systems**: Uses, Formal specification, Formal grammars, Backus–Naur form, Canonic systems.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. J. Donovan, ***Systems Programming***, 1st Edition, McGraw Hill Education, 2017.
T2. S. Pal, ***Systems Programming***, 1st Edition, Oxford University Press, 2012.

Reference Books:

R1. D. M. Dhamdhere, ***Systems Programming and Operating Systems***, 2nd Revised Edition, Tata McGraw-Hill, 1999.
R2. A. R. John, ***Systems Programming***, 1st Edition, Morgan Kaufmann, 2015.

Online Resources:

1. http://infolab.stanford.edu/pub/cstr/reports/cs/tr/66/52/CS-TR-66-52.pdf: Notes by Prof. A. C. Shaw

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

CO1	Explain the working principle of Von Neumann's stored program concept and operations of a General Machine structure.
CO2	Apply mnemonic form of programming to write assembly language programs and design a two-pass assembler.
CO3	Design a two-pass macro processor and visualize various system level features in PL/I.
CO4	Distinguish between various loading schemes and design absolute & direct linking loaders.
CO5	Explain the phases of compilation process and use of formal system & grammars.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	3								1	2		1
CO2	1	2	2	1	2							2	2		1
CO3	3	2	2	3								1	1		1
CO4	3	1	2	2								1	2		1
CO5	3	2	2	2								2	1		2

Type	Code	Statistical Inference	L-T-P	Credits	Marks
PE	18BS2T59		3-0-0	3	100

Objectives	The objective of this course is inculcate statistical thinking in designing data collection, derive insights from visualizing data, obtain supporting evidence for data-based decisions, and construct models for predicting future trends from data.
Pre-Requisites	Basic knowledge of probability & statistics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Distributions Derived from the Normal Distribution: χ^2, t, and F distribution, Sample mean and sample variance; Survey Sampling: Population parameters, Sample random sampling - Expectation and variance of sample mean, Estimation of population variance, Normal approximation to the sampling distribution of $\bar{X}$, Estimation of a ratio.	**9 Hours**
Module-2	Estimation of Parameters & Fitting of Probability Distributions: Fitting the Poisson distribution, Parameter estimation (method of moments, maximum likelihood); Large sample theory for maximum likelihood estimates, Confidence intervals from maximum likelihood estimates, Bayesian approach to parameter estimation, Large sample normal approximation to the posterior, Computational aspects, Efficiency and the Camer-Rao lower bound, Negative binomial distribution, Sufficiency (a factorization theorem, Rao-Blackwell theorem).	**9 Hours**
Module-3	Testing Hypotheses & Assessing Goodness of Fit: The Neyman-Person paradigm - Specification of the significance level, Concept of a p-value, Null hypothesis, Uniformly most powerful tests, Duality of confidence intervals & hypothesis tests, Generalized likelihood ratio test, Likelihood ratio tests for the multinomial distribution, Probability plots, Tests for normality; Summarizing Data: Comparison of location estimates, Estimating variability of location estimates by bootstrap, Measures of dispersion, Boxplots, Exploring relationship with scatter plots.	**8 Hours**
Module-4	Comparing Two Samples: Comparing two independent samples – Methods based on the normal distribution, power, A nonparametric method - the Mann Whitney test, Bayesian approach, Comparing paired samples - Methods based on the normal distribution, Signed rank test, Case studies; Analysis of Variance: One-way layout - Normal theory, F test, Problem of multiple comparisons, Kruskal Wallis test.	**8 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	Analysis of Categorical Data: Fisher's exact test, χ^2 test of homogeneity & independence, matched pairs designs, odds ratios; Simple Linear Regression: Statistical properties of the estimated slope & intercept, Accessing the fit, Correlation & regression.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. A. Rice, ***Mathematical Statistics and Data Analytics***, 3rd Edition, Cengage Learning, 2006.

Reference Books:

R1. L. Wasserman, ***All of Statistics : A Concise Course in Statistical Inference***, 1st Edition, Springer, 2004.

R2. B. Efron and T. Hastie, ***Computer Age Statistical Inference : Algorithms, Evidence, and Data Science***, 1st Edition, Cambridge University Press, 2016.

Online Resources:

1. https://nptel.ac.in/courses/111105043/: by Prof. S. Kumar, IIT Kharagpur
2. https://nptel.ac.in/courses/111/102/111102112/: by Prof. N. Chaterjee, IIT Delhi
3. https://nptel.ac.in/courses/111/105/111105124/: by Prof. S. Kumar, IIT Kharagpur

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

CO1	Describe sampling distributions such as χ^2, t, and F distribution and use them in real life problems.
CO2	Estimate the parameters and fitting of probability distributions.
CO3	Apply methods of tests of hypothesis and goodness of fit.
CO4	Conduct a hypothesis test for a population proportion, make a decision using p-value and draw an appropriate conclusion.
CO5	Analyze categorical data and formulate linear regression model for the given data sets.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Cont'd...

PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	2						1	3	1	3
CO2	3	3	3	2	2	2						1	3	1	3
CO3	3	3	3	2	2	2						1	3	1	3
CO4	3	3	3	2	2	2						1	3	1	3
CO5	3	3	3	2	2	2						1	3	1	3

Type	Code	Mobile Computing	L-T-P	Credits	Marks
PE	18CS2T49		3-0-0	3	100

Objectives	The objective of this course is to study networking principles & wireless communication on cellular networks, wireless internet, wireless devices & satellite systems for unobtrusive connectivity that is always available.
Pre-Requisites	Basic knowledge of computer networks & Internet is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies, and latest trends.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Personal Communication Systems (PCS): Wireless Technologies, Signals and Frequency; Cellular Systems: Structure, Cluster, Frequency Reuse and Splitting; Medium Access Control Mechanisms: SDMA, FDMA, TDMA and CDMA; GSM: Channels, Bands, Architecture, Mobility Management, Handover Detection & Management; GPRS: Architecture, GPRS Interfaces, GPRS Network Protocols.	**8 Hours**
Module-2	Wireless LAN (WLAN): IEEE 802.11 System Architecture, Ad-Hoc and Infrastructural Mode, MAC Frame Format; Bluetooth: Piconet, Scatternet, Protocol stack, Profile; WAP: Architecture, Components, Gateway and Protocol Stack, WML Script: Variables, Control Structure & Functions; IMT 2000 Standards: WCDMA and CDMA 2000.	**9 Hours**
Module-3	Mobile IP: Overview, Requirements, Entities, Agent Advertisement & Discovery, Registration, IP Packet Delivery, Tunneling and Encapsulation; IPv6, DHCP, ICMP; Routing in Ad-hoc Network: DSDV, AODV, DSR, ZRP; Mobile Transport Layer: I-TCP, Snooping TCP, M-TCP, T-TCP; WLL: Architecture, Components, Functionalities; Wireless Enterprise Networks.	**9 Hours**
Module-4	Satellite Communication Networks: Architecture, Handoffs, Mobile Satellite Systems (GEO, LEO, MEO, HEO), Satellite Constellation for Satellite Phone, Case Studies: Iridium, GLOBALSTAR, GLONASS; Virtual Private Network: Features, Remote Access, Site to Site VPN, Protocols; Security Challenges in Mobile Computing: Algorithms & Implementation.	**8 Hours**
Module-5	VoIP & Real Time Protocols: Multimedia Content Delivery in Mobile Network, Introduction to Mobile OS: Android, iOS; Introduction to Application Development for Mobile Platforms, Introduction to Android Studio and Java Programming Language, 3-tier Architecture for Mobile Computing, Design Considerations and Computing through Internet, Internet of Things, Future/Current Trends and Research: A Discussion.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Schiller, ***Mobile Communication***, 2nd Edition, Pearson Education, 2008.

T2. Y. –B. Lin and I. Chlamtac, ***Wireless and Mobile Network Architectures***, 1st Edition, John Wiley & Sons, 2008.
T3. D. Griffith and D. Griffiths, ***Head First Android Development: A Brain-Friendly Guide***, 2nd Edition, O'Reilly Media, 2019.

Reference Books:

R1. V. K. Garg, ***Wireless Communication and Networks***, 2nd Edition, Pearson Education, 2003.
R2. A. K. Talukder, H. Ahmed, and R. Yavagal, ***Mobile Computing***, 2nd Edition, Tata McGraw Hill, 2010.
R3. U. Hansmann, L. Merk, M. Nicklous, and T. Stober, ***Principles of Mobile Computing***, 2nd Edition, Springer, 2003.

Online Resources:

1. https://nptel.ac.in/courses/106/106/106106147/: by Prof. P. Singh and Prof. S. Iyer, IIT Madras
2. https://nptel.ac.in/courses/117/104/117104099/: by Prof. A. K. Jagannatham, IIT Kanpur
3. https://nptel.ac.in/courses/106/106/106106167/: by Prof. D. K. Pillai, IIT Madras

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

CO1	Understand different frequency bands & their communication domains and explain the GSM & GPRS functionalities in cellular network.
CO2	Explain the MAC layer protocols of WLAN, Ad hoc Network and different 2G and 3G standards.
CO3	Implement different protocols of Mobile network and transport layer and analyze their performance.
CO4	Comprehend the access and communication mechanisms of satellite network and VPN with cellular network.
CO5	Use appropriate wireless technologies in commercial and enterprise application developments.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Cont'd...

PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2	1	2								3		3
CO2	3	2	3	2	2								3		3
CO3	3	3	3	3	2	1						1	3		3
CO4	3	3	2	2	2	1							3	1	3
CO5	3	1	2	1	2	1						1	3	2	3

Type	Code	Realtime Systems	L-T-P	Credits	Marks
PE	18CS2T55		3-0-0	3	100

Objectives	The objective of this course is to study the concepts & approaches in the design & analysis of real-time systems covering real-time operating systems, communication, and databases.
Pre-Requisites	Knowledge of operating systems, computer networks, and database management is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples and problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Concept of real-time, Applications of real-time systems, Characteristics of real-time systems, Basic model of real-time system, Safety and reliability, Types of real-time tasks, Timing constraints, Modeling timing constraints.	**8 Hours**
Module-2	**Real-time Task Scheduling**: Basic concepts & terminologies, Types of real-time tasks & their characteristics, Classification of real-time task scheduling algorithms, Clock-driven scheduling, Hybrid scheduler, Event-driven scheduling, EDF scheduling, RMA; Scheduling Real-time Tasks in Multiprocessor and Distributed Systems: Dynamic allocation of tasks, Fault-tolerant scheduling of tasks, Clocks in distributed real-time systems, Centralized and distributed clock synchronization.	**8 Hours**
Module-3	**Resource Sharing & Dependencies**: Resource sharing among real-time tasks, Priority inversion, Priority Inversion Protocol (PIP), Highest Locker Protocol (HLP), Priority Ceiling Protocol (PCP), Different types of priority inversions under PCP, Important features of PCP, Issues in using resource sharing protocol, Handling task dependencies.	**8 Hours**
Module-4	**Real-time Operating Systems**: Time services, Features of a real-time operating system, Unix as a real-time operating system, Windows as a real-time operating system, POSIX, A survey on contemporary real-time operating systems, Benchmarking real-time systems.	**8 Hours**
Module-5	**Real-time Communication & Databases**: Basic concepts of real-time communication, Examples of applications requiring real-time communication, Soft & Hard real-time communication in a LAN, Basic concepts of real-time databases, Example applications of real-time databases, Characteristics of temporal data, Concurrency control in real-time databases, Commercial real-time databases.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. R. Mall, ***Real-Time Systems***, 2nd Edition, Pearson Education, 2010.

Reference Books:

R1. J. W. S Liu, ***Real-Time Systems***, 1st Edition, Pearson Education, 2002.
R2. C. M. Krishna and K. G. Shin, ***Real-Time Systems***, 1st Edition, McGraw-Hill Education, 2017.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105036/: by Prof. R. Mall, IIT Kharagpur
2. https://nptel.ac.in/courses/106/105/106105172/: by Prof. R. Mall, IIT Kharagpur

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

CO1	Describe characteristics & applications of real-time systems and their timing constraints.
CO2	Compare real-time task scheduling algorithms and analyze their schedulability criteria.
CO3	Explain the PIP, HLP & PCP protocols for sharing critical resources among real-time tasks.
CO4	Describe the principles, structure & operation of real-time operating systems and evaluate their suitability for real-time applications.
CO5	Understand the concepts of real-time communication and real-time databases.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	2	1								1		
CO2	3	3	2	2	1							2	3	1	1
CO3	3	3	2	2	2							2	3	1	1
CO4	3	2	2	1	2								1	1	1
CO5	3	2	2	2								2	2	1	1

Type	Code	Advanced Computer Architecture	L-T-P	Credits	Marks
PE	18CS2T61		3-0-0	3	100

Objectives	The objective of this course is to provide the theoretical insights into the design & organization of modern computing systems, including structured design methods, analytical techniques, fundamental architectural issues, and the inherent limitations of the traditional approaches.
Pre-Requisites	Knowledge of computer organization and architecture is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Fundamental Concepts**: Microprocessor and Microcontroller, RISC and CISC architectures, Instruction set architecture, Measuring, Reporting and summarizing the performance, Flynn's classification, UMA, NUMA, Distributed Memory Architecture, Array Processor, Vector Processors.	**10 Hours**
Module-2	**Parallelism**: Pipelining fundamentals, Parallelism, Arithmetic and Instruction pipelining, Pipeline performance and speedup.	**8 Hours**
Module-3	**Hazards**: Pipeline Hazards, Traditional methods to overcome hazards, Branch prediction using BTB, Static and dynamic branch prediction, Scoreboard Technique, Tamasulo's approach.	**8 Hours**
Module-4	**Memory Technologies**: Unified Cache, Split Cache, Data vs. instruction Cache, Cache Coherence, Cache Updating Scheme, Cache optimization, Virtual Memory, TLB. **IO System**: Interface, Data Transfer, Interrupts, Collision Resolution Techniques, Bus Arbitration.	**9 Hours**
Module-5	**Case Studies**: Superscalar Operations, UltraSPARC-II, SIMD Array Processor, ILLIAC-IV. **Interconnection Networks**: Static Networks, Network Topologies, Dynamic Networks.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. J. L. Hennessy and D. A. Patterson, ***Computer Architecture - A Quantitative Approach***, 5th Edition, Morgan Kaufmann, 2012.
T2. K. Hwang and F. A. Briggs, ***Computer Architecture and Parallel Processing***, McGraw-Hill Education, 1986.
T3. C. Hamacher, Z. Vranesic, and S. Zaky, ***Computer Organization***, 5th Edition, McGraw-Hill, 2017.

Reference Books:

R1. D. Sima, T. Fountain, and P. Kacsuk, ***Advanced Computer Architecture : A Design Space Approach***, Addison Wesley, 1997.

R2. J. P. Shen and M. H. Lipasti, ***Modern Processor Design : Fundamentals of Superscalar Processors***, McGraw-Hill Education, 2014.

Online Resources:

1. https://nptel.ac.in/courses/106/103/106103206/: by Prof. J. Jose, IIT Guwahati

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

CO1	Define the fundamentals and compare among various multi-processor architectures.
CO2	Explain the effectiveness of pipelining, classify and compute the speedup thereof.
CO3	Elaborate the hazards of pipeline architecture and various techniques to overcome them.
CO4	Describe cache optimization techniques, virtual memory concepts, and IO mechanisms.
CO5	Compare various industrial processors and explain basics of interconnection networks.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	1								1	2	1	2
CO2	1	1	1	1								1	3	1	2
CO3	2	2	1	1								1	3	1	2
CO4	1	2	2	2								2	2	1	3
CO5	2	1	2	1								2	2	1	3

Type	Code	Biology for Engineers	L-T-P	Credits	Marks
BS	18BS1T11		3-0-0	3	100

Objectives	The objective of this course is to integrate the knowledge of traditional engineering and modern biology to solve problems encountered in living systems, allow engineers to analyze a problem from both an engineering and biological perspective, anticipate specific issues in working with living systems, and evaluate possible solutions.
Pre-Requisites	Basic knowledge of biology, chemistry, and physics is adequate.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction to Biology**: Chemical foundations and basic chemistry of cell – Carbon compounds and cell as a unit of life; Physical and chemical principles involved in maintenance of life processes; Cell Structure & Functions – Ultra-structure and functions of cellular components (Prokaryotic and Eukaryotic cells), cell wall, plasma membrane, endoplasmic reticulum; Biomolecules – Carbohydrates, Lipids, Amino Acids, Proteins, Nucleic acids; Tissue systems – Overview of animal and plant tissue systems.	**8 Hours**
Module-2	**Metabolisms & Cell Division**: Exothermic and endothermic versus endergonic and exergoinc reactions; Concept of Keq and its relation to standard free energy, Spontaneity, ATP as an energy currency, breakdown of glucose (Glycolysis and Krebs cycle) and synthesis of glucose (Photosynthesis), Energy yielding and energy consuming reactions, Concept of Energy charge Morphology of chromosomes; Cell theory – Cell cycle and phases; Mitosis and meiosis.	**8 Hours**
Module-3	**Genetics & Organic Evolutions**: Laws of heredity – Biological indicators, bio-sensors; Mutations – Cause, types and effects on species; Molecular Genetics: Structures of DNA and RNA; Origin of life – Haldane and Oparins concepts; Modern concept of natural selection and speciation – Lamarkism, Darwinism/Neo-Darwinism.	**8 Hours**
Module-4	**Microbiology & Immunology**: Concept of single celled organisms, Concept of species and strains, Identification and classification of microorganisms, Microscopy, Ecological aspects of single celled organisms, Sterilization and media compositions, Growth kinetics. Microbial diseases, epidemiology and public health; Human immune mechanism – Types of immunities; Antigen/Antibody reactions – Applications in human health; Immunological disorders: Auto-immune diseases.	**10 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	**Biochemistry & Biotechnology**: Amino acids & Proteins – Classification based on function and structure; Protein synthesis – Components and regulatory mechanisms; Enzymes – An overview; Biotechnology: Basic concepts on Totipotency and Cell manipulation; Plant & Animal tissue culture – Methods and uses in agriculture, medicine and health.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. Wiley Editorial, ***Biology for Engineers***, John Wiley & Sons, 2018.
T2. McGraw-Hill Editorial, ***Biology for Engineers***, McGraw-Hill Education, 2013.

Reference Books:

R1. A. T. Johnson, ***Biology for Engineers***, 1st Edition, CRC Press, 2010.
R2. S. Singh, T. Allen, ***Biology for Engineers***, 1st Edition, Vayu Education of India, 2014.
R3. C. D. Tamparo and M. A. Lewis, ***Diseases of the Human Body***, 6th Edition, F. A. Davis Co., 2016.
R4. N. A. Campbell, L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky, and J. B. Reece, ***Biology: A Global Approach***, 10th Edition, Pearson Education, 2014.

Online Resources:

1. http://www.dcc-cde.ca.gov/documents/Anita%20Archer%20-%202013/Cell%20Theory.pdf
2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3743984/
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4239820/
4. http://www.euro.who.int/data/assets/pdf_file/0013/102316/e79822.pdf

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

CO1	Understand different types of cells, list their parts, and describe their structural components and the differences between them.
CO2	Know about metabolism and cell theory.
CO3	Comprehend genetics, organic evolution, and the immune system.
CO4	Identify the cause, symptoms, diagnosis and treatment of common diseases.
CO5	Recognize biological processes like protein synthesis, know about action of enzymes and tissue culture.

Program Outcomes Relevant to the Course:

PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						2	2	1	2			1	2	1	1
CO2						2	1	1	1			1	2		1
CO3						3	2	1	1			1	2	1	1
CO4						3	2	1	1			1	2		1
CO5						2	2	1	1			1	2	1	1

Type	Code	Professional Ethics & Values	L-T-P	Credits	Marks
MC	18NC1T03		2-0-0	0	100

Objectives	To enable the students to create an awareness on professional ethics and human values, to instill moral and social values & loyalty to appreciate the rights of others, and to provide the basis for deciding that a particular action is morally good or bad.
Pre-Requisites	Elementary idea on Psychology, sensitivity to professionalism with respect to morality, judgment, and commitment are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, and planned interactive sessions.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Ethics: Basic terms – Moral, Values, Ethics, Personal and Professional Ethics, Ethical Dilemma, Resolving Ethical Dilemma, Emotional Intelligence, Moral Development Theories of Kohlberg and Piaget, Views on Ethics by Aristotle, Governing factors of an individual's value system.	**6 Hours**
Module-2	Profession and Professionalism: Profession, Professional, Professionalism, Professional Accountability, Professional Risks, Conflict of interest, Ethical Theories and their application – Consequentialism, Deontology, Virtue theory, Rights Theory, Casuist theory, Moral Absolutism, Moral Relativism, Moral Pluralism.	**9 Hours**
Module-3	Ethics in Engineering: Engineering as a profession, Engineers as Managers, Constultants, and Leaders, Engineering as social experimentation, Issues in engineering ethics.	**3 Hours**
Module-4	Engineers' Responsibility and Safety: Safety and Risk (underestimating, over estimating, indifference), Risk-benefit analysis, Engineers' Responsibility for Safety.	**3 Hours**
Module-5	Global Ethical Issues: Different ethical issues in Business, Corporate Social Responsibility, Environment, IT, Bioethics, Intellectual Property Rights, Research, and Media.	**7 Hours**
	Total	**28 Hours**

Text Books:

T1. R. Subramanian, ***Professional Ethics***, 2nd Edition, Oxford University Press, 2017.

Reference Books:

R1. M. W. Martin and R. Schinzinger, ***Ethics in Engineering***, Tata McGraw Hill, 2013.
R2. C. E. Harris, M. S. Pritchard, and M. J. Rabins, ***Engineering Ethics - Concepts and Cases***, Thompson Learning, 2003.
R3. D. Albuquerque, ***Business Ethics***, Oxford University Press, 2013.
R4. E. G. Seebauer and R. L. Barry, ***Fundamentals of Ethics***, Oxford University Press, 2012.

R5. R. S. Naagarazan, ***A Text Book on Professional Ethics and Human Values***, 2nd Edition, New Age International, 2016.

Online Resources:

1. https://india.oup.com/orcs/9780199475070/

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

CO1	Learn ethical concepts which will enable them to effectively resolve ethical issues in their personal and professional lives.
CO2	Be aware of their duties and responsibilities as professionals towards their organization and society.
CO3	Gather primary knowledge on engineering ethics and its objectives, different parameters of enquiry and engineering as an experiment in society.
CO4	Be conscious about risk and safety while finding a solution to an engineering problem.
CO5	Become attentive of the different global ethical issues.

Program Outcomes Relevant to the Course:

PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1			2			1	1	3				1		3	1
CO2			1			1	1	3	1	1		1		3	1
CO3			1			1		3		1		1		2	1
CO4			1			1	2	3	1			1		2	1
CO5			1			1	1	3	1	1		1		1	1

Type	Code	Operating Systems Lab	L-T-P	Credits	Marks
PC	18CS1L04		0-0-2	1	100

Objectives	The objective of this laboratory course is to learn operating system level programming and provide a hands-on exposure on implementation of various algorithms of the operating system.
Pre-Requisites	Knowledge of programming, data structures, and concepts of operating systems taught in the theory class are required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Introduction to Linux OS and basic VI editor commands.
2	Linux File Structure and advance Linux commands like `grep`, `pipe`, `cut`, etc.
3	Introduction to UNIX Shell Script: Arithmetic Expressions, Relational and Conditional Operators.
4	UNIX Shell Script: Looping, Switch Cases.
5	Process Creation, process handing, process signaling through `fork()`, `exec()`.
6	CPU Scheduling (Non-Pre-emptive) FCFS, SJF, Priority.
7	CPU Scheduling (Pre-emptive) SRTF, RR, Priority-based preemptive.
8	Multi-Threaded application using POSIX threads.
9	Synchronization using Semaphore (Producer- Consumer, Reader-Writer).
10	Message passing : Pipe and Signals.
11	Inter-process communication using shared memory.
12	Deadlock implementation: Banker's Algorithm.
13	Implementing Page Replacement Algorithms.
14	Implementing Disk scheduling Algorithms.

Text Books:

T1. V. Mukhi, ***The C Odyssey: UNIX***, 1st Edition, BPB Publications, 1992.
T2. A. Silberschatz, P. B. Galvin, and G. Gagne, ***Operating System Concepts***, 8th Edition, Wiley, 2009.

Reference Books:

R1. A. S. Tanenbaum, ***Modern Operating Systems***, 3rd Edition, PHI, 2009.
R2. P. B. Prasad, ***Operating Systems and System Programming***, 2nd Edition, Scitech Publications, 2015.

Online Resources:

1. https://www.technicalsymposium.com/sharelabcodings_os.html
2. https://www.cse.iitb.ac.in/~mythili/teaching/cs347_autumn2016/index.html

P.T.O

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

CO1	Become conversant with various Linux commands and their specific uses.
CO2	Write, debug, and execute UNIX shell scripts for a given problem.
CO3	Implement various scheduling algorithms used at the operating system level.
CO4	Write programs for creation of child processes and communication among them.
CO5	Develop and implement deadlock avoidance and detection algorithms.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	1		1						2			1
CO2	2	2	2	1		1						2	2		
CO3	3	1	2	2		1						2	2		1
CO4	3	2	2	1		1						2	2		
CO5	3	2	3	1		1						2	2		1

Type	Code	Computer Networks Lab	L-T-P	Credits	Marks
PC	18CS1L05		0-0-2	1	100

Objectives	The objective of this laboratory course is to implement various computer networking protocols in a high-level programming language and become acquainted with socket programming & GUI based Network Simulation tools like NetSim/NS3.
Pre-Requisites	Knowledge of C programming and concepts of computer networks taught in the theory class are required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Introduction to Network Hardware and Software, Network Command like Netstat, Tracert, Ping, Pathping, Telnet, FTP.
2	Basic idea about IPv4 addressing and programming to find the IP address of a machine and Ethernet address.
3	To study various types of connector devices: Router, Hub, Switch, Bridge and verification of standard Network topologies: Star, Bus, Ring etc.
4	Introduction to Socket Programming: TCP and UDP sockets.
5	Socket Programming for Echo Client and Echo Server using TCP socket.
6	Socket Programming for Chatting between two Machines using TCP socket.
7	Socket Programming for Echo Client and Echo Server using UDP socket.
8	Socket Programming for communicating between two Machines using UDP socket.
9	Socket Programming for HTTP web page upload and download.
10	C Program to implement ARP/RARP Protocols.
11	Introduction to Network Simulator details (NetSim/NS3).
12	Simulation of different MAC Protocols: ALOHA, CSMA etc.
13	Simulation of Routing Protocol: Link state Routing.
14	Implementation of STOP and Wait Protocol.

Text Books:

T1. R. Stevens and S. A Rago, ***Advanced UNIX Programming***, 3rd Edition, Pearson Education, 2013.
T2. L. V. Winkle, ***Hands-On Network Programming with C***, 1st Edition, Packt Publishing, 2019.

Reference Books:

R1. S. Walton, ***LINUX Socket Programming***, 2nd Edition, SAMS Publication, 2007.
R2. M. J. Donahoo and K. L. Calvert, ***TCP/IP Sockets in C : Practical Guide for Programmers***, 2nd Edition, Morgan Kaufmann, 2009.

Online Resources:

1. http://home.iitk.ac.in/~chebrolu/ee673-f06/sockets.pdf: Socket Programming by Prof. K. Chebrolu, IIT Kanpur
2. https://www.csd.uoc.gr/~hy556/material/tutorials/cs556-3rd-tutorial.pdf

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

CO1	Experiment with transmission media, connector, Hubs, Switches and installation of NIC.
CO2	Implement client server applications with TCP/UDP Socket Programming in a standalone machine and over a network.
CO3	Apply HTTP over TCP/UDP connection with help of a Browser.
CO4	Simulate Datalink layer protocols using NetSim/NS3.
CO5	Develop applications to communicate over heterogeneous networks (Internet).

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	1							2	2	1	3
CO2	3	2	3	1	2							2	2	1	3
CO3	2	3	3	2	3							2	2	1	3
CO4	2	2	2	2								2	3	1	2
CO5	2	2	2	3									3	1	2

Type	Code	Soft Skills & Interpersonal Skills Lab	L-T-P	Credits	Marks
HS	18HS1L02		0-0-4	2	100

Objectives	The objectives of this laboratory course is to practice language skills to become effective communicators by addressing issues like speaking inhibitions. The lab comprises of individual and team activities based on the four skills of language (LSRW).
Pre-Requisites	Basic knowledge of English grammar and the ability to speak, read, and write using the English language is required.
Teaching Scheme	Regular laboratory classes with various tasks designed to facilitate communication through pair and/or team activities with regular assessments, presentations, discussions, role play, audio-visual supplements, writing activities, business writing practices and vocabulary enhancement.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Communication in a nutshell.
2	Communication in a nutshell.
3	Mock GD 1
4	Mock GD 2
5	Mock GD 3
6	Mock GD 4 (Test)
7	Personality Development
8	Assertiveness
9	Teamsmanship
10	Leadership
11	Listening
12	Presentation Skills 1
13	Presentation Skills 2
14	Presentation Skills 3
15	Presentation Skills 4
16	Personal Interview 1
17	Personal Interview 2
18	Personal Interview 3
19	Personal Interview 4
20	Mind Mapping
21	Reading Skills 1
22	Reading Skills 2

Cont'd...

Experiment-#	Assignment/Experiment
23	Writing Skills 1
24	Writing Skills 2
25	Writing Skills 3
26	Verbal Ability 1
27	Verbal Ability 2
28	Verbal Ability 3

Text Books:

T1. M. A. Rizvi, ***Effective Technical Communication***, 2nd Edition, Tata McGraw Hill, 2017.
T2. T. Balasubramaniam, ***English Phonetics for Indian Students***, 3rd Edition, Trinity Press, 2013.
T3. M. Raman and S. Sharma, ***Technical Communication: Principles and Practice***, 3rd Edition, Oxford University Press, 2015.

Reference Books:

R1. S. Samantray, ***Business Communication and Communicative English***, 3rd Edition, Sultan Chand, 2006.
R2. S. John, ***The Oxford Guide to Writing and Speaking***, 3rd Edition, Oxford University Press, 2013.
R3. B. K. Mitra, ***Personality Development and Soft Skills***, 2nd Edition, Oxford University Press, 2016.
R4. B. K. Das *et. al.*, ***An Introduction to Professional English and Soft Skills***, Cambridge University Press, 2009.
R5. B. K. Mitra, ***Effective Technical Communication - A Guide for Scientists and Engineers***, 1st Edition, Oxford University Press, 2006.

Online Resources:

1. https://owl.purdue.edu/owl/purdue_owl.html
2. https://www.usingenglish.com/
3. http://www.english-test.net/
4. https://www.ef.com/wwen/english-resources/

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

CO1	Develop the skills to use English language for effective communication.
CO2	Utilise function of language in context of formality, appropriateness and sensitive issues.
CO3	Formulate and structure sentences using grammatically correct English.
CO4	Compose clear and effective business messages for specific purposes.
CO5	Build up a strong personality and develop skills for efficient public speaking.

Program Outcomes Relevant to the Course:

PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

Cont'd...

PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						3		1	2	3	2	3	1	3	3
CO2								2	2	3	2	3		3	2
CO3										3		3		2	2
CO4								1	1	3		3		3	3
CO5								1	2	3	1	3		3	3

Type	Code	Software Engineering	L-T-P	Credits	Marks
PC	18CS1T06		3-0-0	3	100

Objectives	The objective of this course is to learn the concepts & practices of software engineering starting with different phases of SDLC up to deployment & maintenance covering all facets of software development in industry.
Pre-Requisites	Basic programming knowledge and understanding of databases are required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies, and latest trends.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Software Engineering**: Introduction, Evolving role of software, Legacy software, Software myths, Process framework, CMM, Life-cycle models, Waterfall model, Incremental models, Evolutionary models, Specialized models, Unified process, Agile Process Models (Extreme programming, Crystal, Scrum)	**8 Hours**
Module-2	**Requirements Engineering**: Types of Requirements, Functional and non-functional requirements, The software requirements document, Requirements - specification, engineering processes, elicitation & analysis, validation, and management; Decision Trees and Decision Tables, Formal Specification (Axiomatic specs for Stacks & Queues)	**9 Hours**
Module-3	**Software Project Management**: Software project planning process, Project estimation (Cost, Time, Effort), Decomposition techniques, Empirical estimation models, The Make/Buy decision, Project scheduling, Task network, Critical Path method, PERT Scheduling, Earned Value analysis.	**9 Hours**
Module-4	**Design Engineering**: Function-oriented Software Design (DFD, Structure charts), Object-oriented Design using UML, User Interface design; **Software Testing**: Testing strategies, Types of testing, Black-Box testing, White-box testing, Basis Path testing, Control Structure testing, Reliability testing, Security testing.	**9 Hours**
Module-5	**Advanced Topics**: Testing web-apps, Formal methods, Risk Management, Configuration Management, Re-Engineering, Security Engineering.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. R. S. Pressman, ***Software Engineering : A Practitioners Approach***, 7th Edition, McGraw Hill, 2010.
T2. I. Sommerville, ***Software Engineering***, 9th Edition, Pearson Education, 2011.

Reference Books:

R1. R. Mall, ***Fundamentals of Software Engineering***, 4th Edition, PHI, 2014.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105087/: by Prof. R. Mall, IIT Kharagpur
2. https://nptel.ac.in/courses/106/101/106101163/: by Prof. M. D'souza, IIIT Bangalore
3. https://nptel.ac.in/courses/106/101/106101061/: by Prof. N. L. Sarda, Prof. U. Bellur, and Prof. R. K. Joshi, IIT Bombay
4. https://nptel.ac.in/courses/106/105/106105218/: by Prof. D. P. Mohapatra, NIT Rourkela and Prof. R. Mall, IIT Kharagpur

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

CO1	Understand the SDLC phases and apply suitable life-cycle model in building of software products based on their characteristics.
CO2	Apply various requirement analysis tools for the requirements engineering process.
CO3	Describe the project management components and apply them for cost, time & effort estimation for software development projects.
CO4	Explain the design artifacts, testing strategies and implement them appropriately.
CO5	Achieve competitive advantage and enhanced quality by applying advanced concepts.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	3		1	1				2	1	1	1	1	3
CO2	3	2	1		3	1				2	2	2	3	1	3
CO3	3	2	1		2	3				3	3	2	3	2	3
CO4	3	1	3		3	1				3	3	1	3	1	3
CO5	1	2	2		2	1				1	1	1	2	3	2

Type	Code	Formal Languages & Automata Theory	L-T-P	Credits	Marks
PC	18CS1T07		3-0-0	3	100

Objectives	The objective of this course is to study the mathematical foundations & abstract models of of computation consisting of automata theory, formal languages & grammars, computability and concept of Turing machines.
Pre-Requisites	Basic knowledge of discrete mathematics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction: Automata theory, Computability theory, Complexity theory, Mathematical notations & terminology, Alphabet, String, Languages & operations on strings; Finite Automata (Deterministic): Formal definition, Transition function, Extended transition function, Language of DFA, Design of DFA; Finite Automata (Non-deterministic): Formal definition, Language of NFA, Equivalence of DFA & NFA; NFA with Epsilon Transition: Eliminating ε-transitions from NFA, Conversion from Epsilon-NFA to DFA, Minimization of DFA.	**9 Hours**
Module-2	Moore Machines, Mealy Machines; Regular Expressions: Operators and their precedence, Building Regular expressions, DFA to Regular Expressions, Regular Expressions to DFA, Arden's theorem, Pumping Lemma for Regular languages, Closure properties of Regular languages.	**8 Hours**
Module-3	Introduction to Grammars: Definition, Derivation of string, Left and right linear grammars, Regular grammars; Context Free Grammars: Definition, Derivation of string, Language of CFG, Parse Tree, Ambiguity in grammar, Elimination of ambiguity, Normal forms of CFG: Chomsky and Greibach normal forms, Converting CFG to CNF & GNF, Cook, Younger, Kasami Algorithm, Closure Properties of context free languages.	**9 Hours**
Module-4	Push Down Automata: Basic Model, Components, Moves of a PDA, ID of a PDA, Design of a PDA, PDA to CFG and CFG to PDA conversion, Pumping Lemma for CFL; Turing Machines: Model, Components, ID of TM, Design of a TM, Variation of TM model, Recursively Enumerable Languages, Universal Turing Machine and undecidable problems.	**9 Hours**
Module-5	Church Turing hypothesis, Recursive and recursively enumerable sets, Chomsky's hierarchy of languages. Undecidability of Post correspondence problem, Linear Bounded Automata and Context Sensitive Languages; Primitive Recursive Functions: μ-Recursive functions, Ackermann's function, Turing computable functions, Cantor and Godel numbering; NP Completeness: P and NP, NP complete and NP Hard problems.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. J. E. Hopcroft, R. Motwani, and J. D. Ullman, ***Introduction to Automata Theory, Languages and Computation***, 3rd Edition, Pearson Education, 2007.
T2. P. Linz, ***An Introduction to Formal Languages and Automata***, 4th Edition, Jones & Bartlett Learning, 2006.

Reference Books:

R1. M. Sipser, ***Introduction to the Theory of Computation***, 3rd Edition, Cengage Learning, 2012.
R2. J. C. Martin, ***Introduction to Languages and the Theory of Computation***, 4th Edition, Tata McGraw-Hill, 2010.
R3. K. L. P. Mishra, and N. Chandrasekaran, ***Theory of Computer Science: Automata, Languages and Computation***, 3rd Edition, PHI, 2012.

Online Resources:

1. https://nptel.ac.in/courses/111/103/111103016/: by Dr. K.V. Krishna and Dr. D. Goswami, IIT Guwahati
2. https://nptel.ac.in/courses/106/106/106106049/: by Prof. K. Krithivasan, IIT Madras
3. https://nptel.ac.in/courses/106/105/106105196/: by Prof. S. Mukhopadhyay, IIT Kharagpur
4. https://www.ics.uci.edu/~goodrich/teach/cs162/notes/: by Prof. M. T. Goodrich, University of California, Irvine, USA

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

CO1	Develop and implement mathematical models with DFA, NFA for regular languages and grammar for real life applications.
CO2	Design and implement grammar and PDA for context free languages and demonstrate their properties.
CO3	Construct Turing machines for context sensitive and un-restricted languages.
CO4	Describe the Chomsky hierarchy of Formal Languages and Grammar.
CO5	Illustrate the relevance of the Church-Turing thesis, explain the concept of decidability & recursive enumerability, and classify a given language to the P, NP or NPC complexity classes.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Cont'd...

PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	1							2	3		3
CO2	3	2	3	1	3							2	3		2
CO3	3	3	3	2	3							2	3		2
CO4	2	3	2	2								2	3		2
CO5	2	2	2	3								1	3		2

Type	Code	Machine Learning	L-T-P	Credits	Marks
PC	18CS1T08		3-1-0	4	100

Objectives	The objective of the course is to learn the fundamental concepts behind supervised, unsupervised & reinforcement learning, assess & select appropriate model and use cross validation to tune their parameters.
Pre-Requisites	Basic knowledge of engineering mathematics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Overview of supervised learning, K-nearest neighbour, Multiple linear regression, Shrinkage methods (Ridge regression, Lasso regression), Logistic regression, Linear Discriminant Analysis, Feature selection.	**11 Hours**
Module-2	Bias, Variance, and model complexity, Bias-variance trade off, Bayesian approach and BIC, Cross- validation, Boot strap methods, Performance of Classification algorithms(Confusion Matrix, Precision, Recall and ROC Curve).	**11 Hours**
Module-3	Generative model for discrete data (Bayesian concept learning, Naïve Bayes classifier), SVM for classification, Reproducing Kernels, SVM for regression, Regression and classification trees, Random forest.	**11 Hours**
Module-4	Clustering (K-means, spectral clustering), Feature Extraction (Principal Component Analysis (PCA), kernel based PCA, Independent Component Analysis (IDA), Non-negative matrix factorization), Mixture of Gaussians, Expectation Maximization (EM) algorithm.	**12 Hours**
Module-5	Boosting methods-exponential loss and AdaBoost, Numerical Optimization via gradient boosting; Introduction to Reinforcement Learning, Elements of Reinforcement Learning, Single State Case: K-Armed Bandit, Model-Based Learning (Value Iteration, Policy Iteration).	**11 Hours**
	Total	**56 Hours**

Text Books:

T1. T. Hastie, R. Tibshirani, and J. Friedman, ***The Elements of Statistical Learning - Data Mining, Inference, and Prediction***, 2nd Edition, Springer, 2009.
T2. S. Haykin, ***Neural Networks and Learning Machines***, 3rd Edition, Pearson Education, 2009.
T3. E. Alpaydin, ***Introduction to Machine Learning***, 2nd Edition, Prentice Hall of India, 2010.

Reference Books:

R1. Y. G. James, D. Witten, T. Hastie, and R. Tibshirani, ***An Introduction to Statistical Learning with Applications in R***, 2nd Edition, Springer, 2013.
R2. T. M. Mitchell, ***Machine Learning***, 1st Edition, McGrow-Hill Education, 2013.
R3. C. M. Bishop, ***Pattern Recognition and Machine Learning***, 1st Edition, Springer, 2006.

Online Resources:

1. https://nptel.ac.in/courses/106/106/106106139/: by Dr. B. Ravindran, IIT Madras
2. https://nptel.ac.in/courses/106/105/106105152/: by Prof. S. Sarkar, IIT Kharagpur

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

CO1	Apply the concepts of supervised machine learning and its functionalities.
CO2	Determine most appropriate model in a specific context using model selection techniques.
CO3	Perform classification using Bayes classifier, SVM, Decision Tree, and Random Forest.
CO4	Reduce dimensionality using feature selection and apply unsupervised machine learning for solving problems.
CO5	Apply the basic concepts of boosting methods and reinforcement learning to real life problems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	1							1	3	1	2
CO2	3	3	3	2	1							1	3	1	3
CO3	3	3	3	2	1							1	3	1	3
CO4	3	3	3	2	1							1	3	1	3
CO5	3	3	3	2	1							1	3	1	3

Type	Code	Artificial Intelligence	L-T-P	Credits	Marks
PE	18CS2T29		3-0-0	3	100

Objectives	The objective of the course is to provide a strong foundation of fundamental concepts and goals, methods & techniques of Artificial Intelligence (AI) to build intelligent systems with perception, reasoning, and learning abilities.
Pre-Requisites	Knowledge of basic mathematics, algorithms & data structures is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Artificial Intelligence: Introduction; Intelligent Agents: Agents and Environment, Good Behavior, Nature of Environments, Structure of Agents; Problem Solving: Solving Problems by Searching - Problem-Solving Agents, Example Problems, Searching for Solutions, Uninformed search strategies, Searching with Partial Information.	**8 Hours**
Module-2	Informed Search & Exploration: Informed (Heuristic) search strategies, Heuristic functions, Local Search Algorithms & Optimization Problems; Constraint Satisfaction Problems: Introduction, Backtracking search for CSPs, Local Search for CSPs; Adversarial Search: Games, Optimal Decisions in Games, Alpha-Beta Pruning; Knowledge & Reasoning: Knowledge-Based Agents, The Wumpus World.	**10 Hours**
Module-3	Knowledge and Reasoning: Logic, Propositional Logic, Reasoning Patterns in Propositional Logic; First-Order Logic: Syntax and Semantics of First-Order Logic, Using First-Order Logic, Knowledge Engineering in First-Order Logic; Inference in First-Order Logic: Propositional vs. First-Order Logic, Unification and Lifting, Forward Chaining, Backward Chaining, Resolution; Knowledge Representation: Ontological Engineering , Categories and Objects, Semantic Nets, Frames.	**8 Hours**
Module-4	Planning: The Planning Problem, Planning with State-Space Search, Partial-Order Planning, Planning Graphs; Uncertain Knowledge & Reasoning: Acting under Uncertainty, Bayes Rule and its use; Probabilistic Reasoning: Representing Knowledge in an Uncertain Domain, Semantics of Bayesian Networks.	**8 Hours**
Module-5	Learning: Learning from Observations, Forms of Learning, Inductive Learning, Learning Decision Trees; Statistical Learning, Instance Based Learning, Neural Networks; Reinforcement Learning: Passive and Active Reinforcement Learning; Expert Systems: Introduction, Architecture, Representations.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Russell and P. Norvig, ***Artificial Intelligence - A Modern Approach***, 3rd Edition, Pearson Education, 2016.
T2. D. W. Patterson, ***Introduction to Artificial Intelligence & Expert Systems***, 1st Edition, Pearson Education, 2015.

Reference Books:

R1. E. Rich, K. Knight, and S. B. Nair, ***Artificial Intelligence***, 3rd Edition, McGraw Hill Education, 2009.
R2. G. F. Luger, ***Artificial Intelligence: Structures and Strategies for Complex Problem Solving***, 6th Edition, Pearson Education, 2008.
R3. M. Negnevitsky, ***Artificial Intelligence: A Guide to Intelligent Systems***, 3rd Edition, Addison Wesley, 2.
R4. N. J. Nilson, ***Principles of Artificial Intelligence***, Narosa, 2002.
R5. E. Charniak and D. McDermott, ***Introduction to Artificial Intelligence***, 1st Edition, Addison-Wesley, 1985.

Online Resources:

1. https://nptel.ac.in/courses/106/102/106102220/: by Prof. Mausam, IIT Delhi
2. https://nptel.ac.in/courses/112/103/112103280/: by Prof. S. M. Hazarika, IIT Guwahati
3. https://nptel.ac.in/courses/106/106/106106140/: by Prof. D. Khemani, IIT Madras
4. https://nptel.ac.in/courses/106/106/106106126/: by Prof. D. Khemani, IIT Madras
5. https://nptel.ac.in/courses/106/105/106105079/: by Prof. P. Dasgupta, IIT Kharagpur

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

CO1	Explore agents, environments, and search goal state using uninformed techniques in a state space.
CO2	Apply search techniques for game playing and solving constraint satisfaction problems.
CO3	Interpret logic, inference rules for decision making, and represent knowledge using semantic nets & frames.
CO4	Apply planning and reasoning to handle uncertainty in real life problems.
CO5	Use learning to solve complex real-life problems and design expert systems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Cont'd...

PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3								1	2	1	1
CO2	2	3	2	3								1	3	1	2
CO3	3	2	2	3								1	3	1	1
CO4	3	2	2	2		1						1	3	1	1
CO5	2	2	2	2		2						1	3	1	2

Type	Code	Wireless Sensor Networks	L-T-P	Credits	Marks
PE	18CS2T62		3-0-0	3	100

Objectives	The objective of this course is to provide concepts & unique design challenges presented by wireless sensor networks (WSNs), and introduction to programming for WSNs at the system, network, and application levels.
Pre-Requisites	Knowledge of computer networks and wireless communication is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, applications, and latest research.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Overview of WSN & its technology, motivation & applications, Taxonomy of WSN technologies, Traditional layered stack, Cross-layer designs, Sensor network architecture.	**8 Hours**
Module-2	**Sensor Node Technology**: Overview, Hardware & software, Sensor taxonomy, Wireless network trends, Wireless transmission technology & systems, Radio technology primer, Available wireless technologies, Medium access control protocols for WSN, Fundamentals of MAC protocols, MAC protocols for WSNs, Sensor-MAC case study, IEEE 802.15.4 LR-WPANs Standard case study, MAC protocols analysis using Markov Chain.	**10 Hours**
Module-3	**Routing Protocols**: Data dissemination & gathering, Routing challenges, design issues, and strategies; Transport Control Protocols: Design issues, Resource aware routing, Data-centric routing, Geographic routing, Opportunistic routing.	**10 Hours**
Module-4	**WSN Middleware**: Principles, Architecture, Existing middleware, Network management - requirements, traditional models, design issues; Security issues of WSN: Possible attacks, Countermeasures, Static & dynamic key distribution.	**8 Hours**
Module-5	**WSN Platforms & Tools**: Sensor node Hardware, Berkeley Motes, Programming challenges, Node-level software platforms, Node-level simulators, State-centric programming; Applications of WSNs: Ultra wide band radio communication, Wireless fidelity systems, Future directions, Home automation, Smart metering applications.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. W. Dargie and C. Poellabauer, ***Fundamentals of Wireless Sensor Networks - Theory and Practice***, 1st Edition, Wiley, 2010.

T2. K. Sohraby, D. Minoli, and T. Znati, ***Wireless Sensor Networks - Technology, Protocols, and Applications***, 1st Edition, Wiley InterScience, 2007.

Reference Books:

R1. T. Hara, V. I. Zadorozhny, and E. Buchmann, ***Wireless Sensor Network - Technologies for the Information Explosion Era***, 1st Edition, Springer, 2010.
R2. B. Krishnamachari, ***Networking Wireless Sensors***, 1st Edition, Cambridge University Press, 2005.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105160/: by Prof. S. Misra, IIT Kharagpur

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

CO1	Describe different types of wireless networks, their architecture and supporting protocols.
CO2	Explain the hardware & software of WSNs and MAC layer protocols to address media accessing.
CO3	Analyze the network & transport layer protocols to address issues like addressing, route optimization, handover, and reliability.
CO4	Explain architecture of WSN middleware, identify security issues and apply necessary countermeasures.
CO5	Apply various WSN platforms and tools to design real world applications.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2									1		1		1
CO2	2	2	2	3	3						1		1	1	1
CO3	2	3	2	3	2	1					1		3	1	1
CO4	2	2	3	3	3	1					1		1		2
CO5	2	3	3	3	2	1					1		1		2

Type	Code	Distributed Databases	L-T-P	Credits	Marks
PE	18CS2T38		3-0-0	3	100

Objectives	The objective of this course is to introduce the fundamental concepts, techniques, and challenges of managing large volume of shared data in a parallel and distributed environment, and provide insight into related research.
Pre-Requisites	Knowledge of relational database management systems is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies, and research.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction, Features of Distributed vs. Centralized Databases, Need of Distributed Databases, Components of DDBMSs, Types of Accesses, Review of Relational Model, Applications, Programs, and Transactions, Levels of Distribution Transparency, Reference Architecture for DDBs, Types of Data Fragmentation, An example DDB, Distribution Transparency for Read-Only & Update Applications, Distributed Database Access Primitives, Integrity Constraints in DDBs.	**8 Hours**
Module-2	Distributed Database Design, Framework, Objectives, and Approaches, Design of Database Fragmentation, Horizontal Fragmentation, Distributed Join Graphs, Vertical and Mixed Fragmentation, Allocation of Fragments, Equivalence Transformations For Queries, Transforming Global Queries into Fragment Queries, Algebra of Qualified Relations, Simplification of Fragmented Relations, Semi-join Programs, Distributed Grouping and Aggregate Functions, Parametric Queries.	**9 Hours**
Module-3	Framework for Query Optimization, Problems and Objectives, New model for Queries, Database Profiles, Assumptions and Importance of Distributed Query Optimization, Join Queries, Use of Semi-join Programs, Determination of Semi-join Programs in SDD-1, Determination of Semi-join Programs by AHY Algorithm, Use of Joins for Query Processing, The R* Approach, General Queries, Effect of Commuting Joins and Unions.	**9 Hours**
Module-4	Framework for Transaction Management, Properties and Goals, Supporting Atomicity of Distributed Transactions, Communication Failures, Recovery of Distributed Transactions, The 2-Phase Commitment Protocol, Lock-based Concurrency Control for Distributed Transactions, Deadlock Detection, Architectural Aspects of Distributed Transactions, Distributed Concurrency Control, Serializability in Distributed Databases, Distributed Deadlocks.	**8 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	Concurrency Control Based on Timestamps, Optimistic Methods for Distributed Concurrency Control, Reliability - Basic Concepts, Non-blocking Commitment Protocols, Reliability and Concurrency Control, Determining a Consistent View of the Network, Detection and Resolution of Inconsistency, Checkpoints And Cold Restart, Distributed Database Administration, Catalog Management, Authorization and Protection.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Ceri and G. Pelagatti, ***Distributed Databases: Principles and Systems***, 1st Edition, McGraw-Hill, 2008.

Reference Books:

R1. M. T. Özsu and P. Valduriez, ***Principles of Distributed Database Systems***, 3rd Edition, Springer, 2010.
R2. S. K. Rahimi and S. H. Frank, ***Distributed Database Management Systems***, 1st Edition, Wiley-IEEE Computer Society, 2011.
R3. D. Bell and J. Grimson, ***Distributed Database Systems***, 1st Edition, Addison-Wesley, 1992.

Online Resources:

1. https://www.tutorialspoint.com/distributed_dbms

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

CO1	Describe the fundamental concepts, architecture and data fragmentation in distributed databases.
CO2	Design distributed databases with fragmentation & allocation of data, and explain query execution in a distributed environment.
CO3	Apply query optimization strategies for query execution in a distributed database system.
CO4	Visualize transaction processing and lock based concurrency control in distributed databases.
CO5	Describe timestamp-based concurrency control, reliability and administration of distributed databases.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

Cont'd...

PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	1		2						1	2	2	2
CO2	3	3	3	2	1	1						1	3	2	2
CO3	3	3	3	2	1	1						1	3	2	2
CO4	3	3	3	2	1	1						1	2	2	2
CO5	3	2	1	1	1	2						1	3	2	2

Type	Code	Natural Language Processing	L-T-P	Credits	Marks
PE	18CS2T50		3-0-0	3	100

Objectives	The objective of this course is to study fundamentals, algorithms, and techniques to enable processing of human languages by computers in order to design different human-computer interactive systems.
Pre-Requisites	Knowledge on grammar rules, statistics, regular expressions, and automata theory is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, problem solving, and latest advances.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction to NLP**: Need for processing natural languages, issues and processing complexities, Overview of phases of natural language processing; Language Modeling: Grammar based language models, Statistical modelling, n-gram model.	**8 Hours**
Module-2	**Word Level Analysis**: Use of Regular expressions, Use of finite state automata, Morphological parsing, Spelling error detection and correction, Part of speech tagging.	**8 Hours**
Module-3	**Syntactic Analysis**: Phrase and sentence level constructions, Parsing: Top-down parsing, Bottom-up parsing, A basic top-down parser, The Earley parser, The CYK Parser, Probabilistic parsing.	**9 Hours**
Module-4	**Semantic Analysis**: Meaning representation, Meaning structure of languages, WordNet, Internal structure of words, Ambiguity, Word sense disambiguation, Discourse Analysis: Anaphora resolution, Discourse structure, Natural Language Generation.	**9 Hours**
Module-5	**Advanced Applications**: Information Retrieval System, Machine Translation System, Question Answering System, Text Summarization, Other applications.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. D. Jurafsky and J. H. Martin, ***Speech and Language Processing – An introduction to Language Processing, Computational Linguistics, and Speech Recognition***, 2nd Edition, Pearson Education, 2013.

T2. T. Siddiqui and U. S. Tiwary, ***Natural language Processing and Information Retrieval***, 1st Edition, Oxford University Press, 2008.

Reference Books:

R1. J. Allen, ***Natural Language Understanding***, 2nd Edition, Pearson Education, 2008.

R2. C. D. Manning and H. Schütze, ***Foundations of Statistical Natural Language Processing***, 2nd Edition, MIT Press, 2000.

Online Resources:

1. https://nptel.ac.in/courses/106/101/106101007/: by Prof. P. Bhattacharyya, IIT Bombay
2. https://nptel.ac.in/courses/106/105/106105158/: by Prof. P. Goyal, IIT Kharagpur
3. https://nlp.stanford.edu/fsnlp/
4. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-863j-natural-language-and-the-computer-representation-of-knowledge-spring-2003/lecture-notes/

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

CO1	Explain the fundamental concepts and grammar based models for natural language processing.
CO2	Apply various word-level analysis techniques to convert natural languages into computer processible form.
CO3	Perform syntactic analysis of natural languages using various parsing techniques.
CO4	Derive unambiguous contextual meaning of natural languages by semantic analysis.
CO5	Appreciate applications of NLP in various human-computer interactive systems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	2						1	2		2
CO2	3	3	2	3	2	2						2	3		3
CO3	3	2	2	2	2	2						2	3		3
CO4	3	3	3	3	3	3						3	3		3
CO5	3	3	3	3	3	3						3	3		3

Type	Code	Cloud Computing	L-T-P	Credits	Marks
PE	18CS2T32		3-0-0	3	100

Objectives	The objective of this course is to study fundamental concepts of cloud computing platforms, technologies, service & deployment models, commercial implementations, and security aspects of applications on cloud.
Pre-Requisites	Knowledge on computer networking, client-server concepts, internet & web technologies is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies, and latest trends.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Client/Server systems, Thin & Thick Clients, Centralized computing, Parallel & Distributed Computing, Amdahl's Law, P2P Computing, Cluster Computing, Grid Computing, Utility Computing, Autonomic Computing, Hosting, Data Center, Evolution of Computing Paradigms, Convergence of Technologies, Role of Open Standards.	**8 Hours**
Module-2	The NIST Model of Cloud Computing, Characteristics, Deployment Models, Service Models & their comparison, Disadvantages, Cloud Computing Stack, Virtualization, Types of Hypervisors, Levels of Virtualization, Requirements of VMM, Hypervisor & the Xen Architecture, Types of Virtualization, Memory Virtualization, Storage Virtualization, Load Balancing, Horizontal & Vertical Scaling.	**9 Hours**
Module-3	Cloud Implementations: Infrastructure as a Service (IaaS) – Amazon Web Services, Elastic Compute Cloud (EC2), Simple Storage Service (S3), Simple Queuing Service (SQS), VMWare vCloud, vCloud Express; Platform as a Service (PaaS) – Google App Engine, Java & Python Runtime Environments, Google File System, Google BigTable.	**9 Hours**
Module-4	Windows Azure, SQL Azure, Windows Azure AppFabric; Software as a Service (SaaS): Introduction, Web Services, Web 2.0, Web OS, Case studies on SaaS - SalesForce.com, Force.com, LiveMesh, MS Office Live, Google Apps; Service Level Agreements, Billing & Accounting in SaaS models.	**8 Hours**
Module-5	Cloud Security: Infrastructure Security - Network level, Host level, Application level, Data Security – Aspects, Mitigation, Provider Data & its Security, Identity & Access Management, Trust Boundaries, Challenges, Definitions, Architecture & Practice, IAM Standards & Protocols, Access Control, Privacy, Audit & Compliance.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. K. Hwang, G. C. Fox, and J. J. Dongarra, ***Distributed and Cloud Computing - From Parallel Processing to the Internet of Things***, 1st Edition, Elsevier, 2012.

T2. B. Sosinsky, ***Cloud Computing Bible***, 1st Edition, Wiley-India, 2011.
T3. T. Mather, S. K. Swamy, and S. Latif, ***Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance***, 1st Edition, O'Reilly Media, 2009.

Reference Books:

R1. A. T. Velte, T. J. Velte, and R. Elsenpeter, ***Cloud Computing: A Practical Approach***, 1st Edition, McGraw-Hill Education, 2017.
R2. A. Bahga and V. Madisetti, ***Cloud Computing: A Hands-On Approach***, 1st Edition, Orient Blackswan, 2014.
R3. T. Erl, Z. Mahmood, and R. Puttini, ***Cloud Computing: Concepts, Technology & Architecture***, 1st Edition, Pearson India Education, 2014.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105223/: by Prof. S. K. Ghosh, IIT Kharagpur
2. https://nptel.ac.in/courses/106/105/106105167/: by Prof. S. K. Ghosh, IIT Kharagpur
3. https://nptel.ac.in/courses/106/104/106104182/: by Dr. R. Misra, IIT Kanpur
4. http://web.mit.edu/6.897/www/readings.html: by Prof. H. Balakrishnan, MIT

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

CO1	Define different types of computing paradigms and concepts of cloud technologies.
CO2	Explain the cloud computing architecture, models, and various virtualization techniques.
CO3	Understand the IaaS and PaaS implementations by leading vendors in the industry.
CO4	Appreciate the SaaS model implementations and importance of SLA in cloud environment.
CO5	Describe various aspects of security, privacy, and performance in cloud environments.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

Cont'd...

PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		1			1				1			1		1
CO2	3		3	1	2	1			1	1		1	1		1
CO3	2		2	1	3	1			2	1		1	1	1	2
CO4	2		2	1	3	1			2	1		1	2	1	2
CO5	3		3	2	2	2			2	1		1	2	2	1

Type	Code	Parallel & Distributed Systems	L-T-P	Credits	Marks
PE	18CS2T52		3-0-0	3	100

Objectives	The objective of this course is to study the concepts of parallel and distributed computing including models, design of parallel algorithms, solving complex problems by parallel computation, and performance evaluation.
Pre-Requisites	Knowledge on computer architecture, operating systems, programming and data structures is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on problem solving & programming.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction, Motivating Parallelism, Scope of Parallel Computing; Parallel Programming Platforms - Implicit parallelism, Limitation of Memory System Performance, Dichotomy of Parallel Computing Platforms, Physical Organization of Parallel Platforms, Communication Costs of Parallel Machines, Routing Mechanism for Interconnection Networks, Impact of Process-processor Mapping & Mapping Techniques.	**8 Hours**
Module-2	Principles of Parallel Algorithm Design - Preliminaries, Decomposition Techniques, Characteristics of Tasks & Interactions, Mapping Techniques for Load Balancing, Parallel Algorithm Models; Analytical Modeling of Parallel Programs - Sources of Overheads, Performance Metrics, Effect of Granularity on Performance.	**9 Hours**
Module-3	Scalability of Parallel Systems, Minimum Execution Time and Minimum Cost-optional Execution Time, Asymptotic Analysis of Parallel Programs; Basic Communication Operations - One-to-All Broadcast and All-to-One Reduction, All-to-All Broadcast and Reduction.	**8 Hours**
Module-4	All-Reduce and Prefix-Sum operations, Scatter and Gather, All-to-All Personalized Communication, Circular Shift, Improving the Speed of some Communication Operations, Programming using the Message Passing Paradigm - Introduction, Building Blocks.	**8 Hours**
Module-5	Message Passing Interface (MPI), Communication and Computation; Dense Matrix Algorithms - Matrix-Vector Multiplication, Matrix-Matrix Multiplication (basic algorithm), Solving a System of Linear Equations (Gaussian); Sorting - Issues in Sorting on Parallel Computers, Bubble Sort and its Variants (Odd-Even Transposition); Distributed Systems - Definition, Goal, Types, Architectures, Key Characteristics.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. A. Grama, G. Karypis, V. Kumar, and A. Gupta, ***Introduction to Parallel Computing***, 2nd Edition, Pearson Education, 2004.

T2. M. J. Quinn, ***Parallel Computing: Theory and Practice***, 2nd Edition, McGraw-Hill, 2017.

Reference Books:

R1. C. Lin and L. Snyder, ***Principles of Parallel Programming***, 1st Edition, Pearson Education, 2009.
R2. M. J. Quinn, ***Parallel Programming in C with MPI and OpenMP***, 1st Edition, McGraw-Hill Education, 2004.
R3. B. Wilkinson, ***Parallel Programming: Techniques and Applications Using Networked Workstations and Parallel Computers***, 2nd Edition, Pearson Education, 2005.
R4. Y. Robert, H. Casanova, and A. Legrand, ***Parallel Algorithms***, 1st Edition, CRC Press, 2009.
R5. H. F. Jordan and G. Alagband, ***Fundamentals of Parallel Processing***, 1st Edition, PHI, 2003.

Online Resources:

1. https://nptel.ac.in/courses/106/102/106102114/: by Dr. S. Kumar, IIT Delhi
2. https://nptel.ac.in/courses/106/103/106103188/: by Prof. S. Gopalan, IIT Guwahati
3. https://nptel.ac.in/courses/106/102/106102163/: by Dr. Y. Sabharwal, IIT Delhi
4. https://nptel.ac.in/courses/106/104/106104120/: by Prof. P. Gupta, IIT Kanpur

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

CO1	Assess the performance, limitations, routing, and process-processor mapping techniques in parallel computing architectures.
CO2	Design parallel algorithms using decomposition, load balancing, and interaction overheads.
CO3	Investigate & analyze the basic communication operations in parallel models.
CO4	Explore the advance communication operations in parallel models.
CO5	Apply parallel programming models for solving complex problems using MPI.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	1									3	1	1
CO2	3	3	3	1									3	1	1
CO3	3	3	3	3									3	1	1
CO4	3	3	2	1									3	1	1
CO5	3	3	3	3									3	1	3

Type	Code	Software Engineering Lab	L-T-P	Credits	Marks
PC	18CS1L06		0-0-2	1	100

Objectives	The objective of this laboratory course is to impart hands on exposure on different phases of end-to-end software development including technical writing, architectural design & documentation. The experiments shall go hand-in-hand with the topics taught in the theory class.
Pre-Requisites	Knowledge of object-oriented concepts and skill on MS office is required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of analysis, designing, and documentation.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Problem Statement for a suggested system of relevance.
2	Requirement analysis for the suggested system.
3	Development of SRS for the suggested system.
4	Structured Analysis & Design using DFD, Structure Charts & Data Dictionary.
5	Object Oriented Analysis & Design – Use Case Diagram.
6	Develop the structural view for the system: Class diagram, Object diagram.
7	Construct the behavioral view diagram : State-chart diagram, Activity diagram.
8	Behavioral view diagram : Sequence.
9	Behavioral view diagram : Collaboration.
10	Develop test cases for various types of testing for a sample code of a suggested system.
11	Perform Estimation of effort/cost using FP/COCOMO estimation for chosen system.
12	Prepare time line chart/Gantt Chart/PERT Chart/Activity Diagram for the suggested system.

Text Books:

T1. R. S. Pressman, ***Software Engineering : A Practitioners Approach***, 7th Edition, McGraw Hill, 2010.
T2. I. Sommerville, ***Software Engineering***, 9th Edition, Pearson Education, 2011.

Reference Books:

R1. R. Mall, ***Fundamentals of Software Engineering***, 4th Edition, PHI, 2014.

Online Resources:

1. https://nptel.ac.in/courses/106/101/106101061/: by Prof. N. L. Sarda, Prof. U. Bellur, and Prof. R. K. Joshi, IIT Bombay
2. https://nptel.ac.in/courses/106/105/106105087/: by Prof. R. Mall, IIT Kharagpur
3. https://nptel.ac.in/courses/106/101/106101163/: by Prof. M. D'souza, IIIT Bangalore
4. https://nptel.ac.in/courses/106/105/106105218/: by Prof. D. P. Mohapatra, NIT Rourkela and Prof. R. Mall, IIT Kharagpur

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

CO1	Analyze the characteristics of different applications and evaluate the suitability of life cycle models to such applications.
CO2	Develop the SRS document as per internationally accepted industrial standards.
CO3	Apply the different design artifacts and develop an architectural solution for different applications.
CO4	Describe the different testing strategies and develop test cases for testing of a software.
CO5	Use a project management tool for scheduling & estimation.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	1		1					2	1		3	1	3
CO2	2	1	2		2					2	1		3	2	3
CO3	1	1	3		2					1	1		3	2	3
CO4	1	1	1		3					1	1		3	2	3
CO5	1	1	2		3					1	3		3	2	3

Type	Code	Formal Languages & Automata Theory Lab	L-T-P	Credits	Marks
PC	18CS1L07		0-0-2	1	100

Objectives	The objective of this laboratory course is to implement various models of automaton such as DFA, NFA, PDA, and Turing machine etc., design grammar for various formal languages, and study their limitations.
Pre-Requisites	Knowledge of programming and data structures using C is required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments as per the topics taught in corresponding theory class.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Write C programs to implement various string processing operations.
2	Design DFA's accepting the following strings over the alphabet {0,1}: a. The set of all strings such that the number of 1's is even and the number of 0's is a multiple of 3. b. The set of all strings not containing 110. c. All strings with at least one 1 and exactly two 0's. d. The set of all strings not containing 110.
3	Design NFA's accepting the following languages: a. $\{ababn : n \geq 0\} \cup \{aban : n \geq 0\}$ b. {ab, abc}* c. All strings having a at the third position from right. d. All strings with exactly two a's and more than two b's
4	Implement a C program to convert a given NFA to its equivalent DFA.
5	Write a program to minimize a given DFA.
6	Write a program to implement epsilon-NFA.
7	Design an ϵ-NFA for the given regular expression.
8	Write a program to implement CYK membership algorithm to check whether a given string w can be generated using a given CFG or not.
9	Hands-on with JFLAP Simulator.
10	Using Pumping Lemma, find out the language which is not regular. For each of the language, clearly mention the value of n, w, x, y, z and k using which you could find that the language is regular/not regular using JFLAP Simulator: a. $L = \{a^n b^n : n \geq 0\}$ b. $L = \{ww^R : w \in \{a, b\}^*\}$ c. $L = \{ w \in \{a, b\}^* : na(w) < nb(w)\}$ d. $L = \{a^n b^k c^{n+k} : n \geq 0, k \geq 0\}$

Cont'd...

Experiment-#	Assignment/Experiment
11	Using Pumping Lemma for Context free languages, find out the language which is not a CFL. For each of the language clearly mention the value of n, u, v, w, x, y, and k using which you could find that the language is context free / not using JFLAP Simulator: a. $L = \{a^n b^n c^n : n \geq 0\}$ b. $L = \{ww^R : w \in \{a, b\}^*\}$
12	Design of Context Free Grammar using JFLAP Simulator: a. $L = \{a^n b^n \mid n \geq 0\}$ b. $L = \{w \mid w$ is a palindrome$\}$ c. $L = \{a^i b^j c^k \mid i, j, k \geq 0, i = j$ or $j=k\}$ d. $L = \{w \mid w$ is string of a and b and na(w) = nb(w)$\}$
13	Design of Pushdown Automata for the following languages using JFLAP Simulator: a. $L = \{a^n b^n \mid n \geq 0\}$ b. $L = \{w \mid w$ is a palindrome$\}$ c. $L = \{ww^R : w \in \{a, b\}^*\}$ d. $L = \{ w \in \{a, b\}^* : na(w) < nb(w)\}$
14	Design of Turing Machine using JFLAP Simulator: a. $L = \{a^n b^n \mid n \geq 0\}$ b. $L = \{a^n b^n c^n \mid n \geq 0\}$ c. TM that copies strings of 1's. d. Let x and y be two positive integers represented in unary notation. Construct a TM that will halt in a final state qy if $x \geq y$ and will halt in a non-final state qn if $x < y$.

Text Books:

T1. J. E. Hopcroft, R. Motwani, and J. D. Ullman, ***Introduction to Automata Theory, Languages and Computation***, 3rd Edition, Pearson Education, 2007.
T2. P. Linz, ***An Introduction to Formal Languages and Automata***, 4th Edition, Jones & Bartlett Learning, 2006.

Reference Books:

R1. M. Sipser, ***Introduction to the Theory of Computation***, 3rd Edition, Cengage Learning, 2012.
R2. J. C. Martin, ***Introduction to Languages and the Theory of Computation***, 4th Edition, Tata McGraw-Hill, 2010.
R3. K. L. P. Mishra, and N. Chandrasekaran, ***Theory of Computer Science: Automata, Languages and Computation***, 3rd Edition, PHI, 2012.

Online Resources:

1. https://nptel.ac.in/courses/111/103/111103016/: by Dr. K.V. Krishna and Dr. D. Goswami, IIT Guwahati
2. https://nptel.ac.in/courses/106/106/106106049/: by Prof. K. Krithivasan, IIT Madras
3. https://nptel.ac.in/courses/106/105/106105196/: by Prof. S. Mukhopadhyay, IIT Kharagpur
4. https://www.ics.uci.edu/~goodrich/teach/cs162/notes/: by Prof. M. T. Goodrich, University of California, Irvine, USA

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

CO1	Analyze the characteristics of different applications and evaluate the suitability of life cycle models to such applications.
CO2	Design and write programs to implement DFA.
CO3	Simulate the computation of strings on an NFA.

Cont'd...

CO4	Construct programs to convert NFA to its equivalent DFA.
CO5	Design and write programs to implement CYK algorithm to check the membership of a string in a CFG.
CO6	Simulate CFG, Push-down automaton and Turing Machine for context sensitive languages.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	1							2	2		2
CO2	3	2	3	1	3							2	2		2
CO3	3	3	3	2	3							2	2		2
CO4	2	3	2	2								2	2		2
CO5	2	2	2	3									2		2

Type	Code	Internet & Web Technology Lab	L-T-P	Credits	Marks
PC	18CS1L10		0-0-4	2	100

Objectives	The objective of this course is to provide hands-on exposure on development of static & dynamic web pages using client-side and server-side programming with database connectivity and deployment of web applications.
Pre-Requisites	Knowledge on programming, databases, internet and browsers is required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Study of Web Browsers - Internet Explorer, Chrome, Mozilla Firefox; Browser Settings and options, security features, Cookies, temporary files etc.
2	Working of Application Layer Protocols - HTTP, FTP and SMTP.
3	HTML - Basics of HTML, text, image, MIME types, lists, tables.
4	Creating Web Forms and Use of HTTP GET & POST Methods.
5	Embedding audio and video, Image Map and Anchor Tag.
6	CSS - Introduction to Style Sheets.
7	Use of CSS2, CSS3, DIV and SPAN tags.
8, 9	JavaScript - Introduction to Client side Script, DOM (Document Object Model).
10, 11	JavaScript - Use of Different Elements of DOM, Form, Client Side Validation.
12	Introduction to PERL script and PERL Interpreter.
13	Text processing in PERL.
14	FORM handling in PERL.
15	Server Side Scripting - Introduction to Web Server Architecture (APACHE/IIS)
16	Server Side Scripting - Overview of PHP/JSP.
17	Server Side Scripting - Practice of PHP/JSP – Creating dynamic web pages.
18	XML - Introduction to Extensible Markup Language.
19	Database connection using MySQL.
20	FORM data handling and validation
21	Project Assignment (requirements, test scenarios & implementation criteria).
22-27	Development of assigned project using various web technologies taught.
28	Demonstration of working project, presentation, viva and evaluation.

Text Books:

T1. Kogent Learning Solutions, ***Web Technologies: Black Book***, 1st Edition, Dreamtech Press, 2009.

Reference Books:

R1. T. A. Powell, ***The Complete Reference HTML and CSS***, 5th Edition, McGraw-Hill, 2017.
R2. M. C. Brown, ***Perl: The Complete Reference***, 2nd Edition, McGraw-Hill, 2001.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105084/: Prof. I. Sengupta, IIT Kharagpur
2. https://www.w3schools.com: HTML & CSS with working examples
3. https://www.tutorialspoint.com/html/html_javascript.htm: Javascript working examples and practice sets
4. https://perlmaven.com/perl-tutorial: Perl tutorial

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

CO1	Explain the working of Browsers and Internet protocols.
CO2	Develop web pages using HTML and CSS.
CO3	Develop interactive Web pages using Java script and XML.
CO4	Use Web server software and Server side scripts to develop & deploy websites.
CO5	Create and host fully fledged user interactive site, using Web tools and languages.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	2							2	1		
CO2	2	2	3	1	3							2	1		
CO3	3	3	2	2	2							2	1	1	1
CO4	2	3	2	2								2	2	1	1
CO5	2	2	2	3									2	1	1

Type	Code	Skill Lab & Project - I	L-T-P	Credits	Marks
PJ	18CS6L03		0-0-4	2	100

Objectives	This laboratory course focuses on overall skill development of through problem formulation, designing, development and implementation of models as solution for the identified problem. Students will be introduced to different open source tools to carry out the assigned project, finishing with project demonstration, report, presentation, viva, and evaluation.
Pre-Requisites	Knowledge on programming languages like C, C++, Java, Python, RDBMS tools such as PL/SQL, PostreSQL, front-end tools and Scientific Document preparation tools are required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher, and shall comprise of programming assignments leading to a complete project.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Problem Identification – I.
2	Problem Identification – II.
3	Problem Formulation.
4	Designing the Model – I.
5	Designing the Model – II.
6	Database Design – I.
7	Database Design – II.
8	Development and Implementation of Model – I.
9	Development and Implementation of Model – II.
10	Development and Implementation of Model – III.
11	Development and Implementation of Model – IV.
12	Interim Project Presentation & Viva.
13	Development and Implementation of Model – V.
14	Development and Implementation of Model – VI.
15	Development and Implementation of Model – VII.
16	Development and Implementation of Model – VIII.
17	Development and Implementation of Model – IX.
18	Development and Implementation of Model – X.
19	GUI Development – I.
20	GUI Development – II.
21	GUI Development – III.
22	Performance Analysis and Testing – I.

Cont'd...

Experiment-#	Assignment/Experiment
23	Performance Analysis and Testing – II.
24	Project Report Preparation – I.
25	Project Report Preparation – II.
26	Project Report Preparation – III.
27	Project Report Preparation – IV.
28	Final Project Presentation & Viva.

Text Books:

T1. B. W. Kernighan and D. M. Ritchie, ***The C Programming Language***, 2nd Edition, Pearson Education, 2015.
T2. H. Schildt, ***The Complete Reference C++***, 4th Edition, McGraw-Hill, 2003.
T3. H. Schildt, ***Java - The Complete Reference***, 9th Edition, McGraw-Hill, 2014.
T4. R. Sedgewick, K. Wayne, and R. Dondero, ***Introduction to Programming in Python : An Interdisciplinary Approach***, 1st Edition, Pearson Education, 2016.

Reference Books:

R1. Z. A. Shaw, ***Learn C the Hard Way: Practical Exercises on the Computational Subjects You Keep Avoiding (Like C)***, 1st Edition, Addison Wesley, 2015.
R2. B. Stroustrup, ***The C++ Programming Language***, 4th Edition, Addison-Wesley, 2013.
R3. E. Matthes, ***Python Crash Course: A Hands on Project-based Introduction to Programming***, 2nd Edition, William Pollock, 2019.

Online Resources: *There are a number of online resources available for this course. The student is advised to search on the Internet and locate the required study materials as per advise of the teacher.*

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

CO1	Identify different real-life problems from a given situation or environment.
CO2	Design and develop mathematical models for the existing problems.
CO3	Implement the proposed models by some programming languages or tools.
CO4	Test the model using test cases for practical implementation in real-life as a product.
CO5	Deploy the model and contribute it as a product to the society.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

Cont'd...

PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3			2		3		2		2	2	3	3	3
CO2	1				3		3		3		2	2	3		3
CO3	1		3	2	3	2	2		3		2	2	3		3
CO4	1	1	3	2	3	2			2			2	3	3	3
CO5	1	1			2	1	1		1			1	3	3	3

Part IV

4th Year B. Tech. (CSE)

Curriculum Structure (Regular)

Semester VII								
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
PC	18CS1T09	Soft Computing	3	1	0	3	1	0
PC	18CS1T10	Computer Graphics	3	0	0	3	0	0
PE	18**2T**	Professional Elective - V	3	0	0	3	0	0
PE	18**2T**	Professional Elective - VI	3	0	0	3	0	0
OE	18**3T**	Open Elective - I	3	0	0	3	0	0
OE	18**3T**	Open Elective - II	3	0	0	3	0	0
PRACTICAL								
PC	18CS1L09	Soft Computing Lab	0	0	2	0	0	1
PJ	18IR6L04	Summer Internship - III	0	0	0	0	0	1
		SUB-TOTAL	**18**	**1**	**2**	**18**	**1**	**2**
		TOTAL	**21**			**21**		

Semester VIII								
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
OE	18**3T**	Open Elective - III	3	0	0	3	0	0
OE	18**3T**	Open Elective - IV	3	0	0	3	0	0
PRACTICAL								
PJ	18IR6L05	Project - II	0	0	16	0	0	8
PJ	18IR6L06	Presentation Skills & Technical Seminar	0	0	4	0	0	2
VV	18VV6L07	Comprehensive Viva	0	0	0	0	0	1
		SUB-TOTAL	**6**	**0**	**20**	**6**	**0**	**11**
		TOTAL	**26**			**17**		

Note: *Courses offered under each elective are given in "List of Electives" on Page 167.*

Curriculum Structure (PS-7)

(For Students opting for Practice School / Industry Internship in the 7th Semester)

Semester VII									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
PRACTICAL									
PS		Practice School / Industry Internship	0	0	0	0	0	16
PJ		Summer Internship - III	0	0	0	0	0	1
		SUB-TOTAL	**0**	**0**	**0**	**0**	**0**	**17**
		TOTAL	**0**			**17**		

Semester VIII									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
PC	18CS1T09	Soft Computing	3	1	0	3	1	0
PC	18CS1T10	Computer Graphics	3	0	0	3	0	0
PE	18**2T**	Professional Elective - V	3	0	0	3	0	0
PE	18**2T**	Professional Elective - VI	3	0	0	3	0	0
OE	18**3T**	Open Elective - III	3	0	0	3	0	0
OE	18**3T**	Open Elective - IV	3	0	0	3	0	0
PRACTICAL									
PC	18CS1L09	Soft Computing Lab	0	0	2	0	0	1
VV	18VV6L07	Comprehensive Viva	0	0	0	0	0	1
		SUB-TOTAL	**18**	**1**	**2**	**18**	**1**	**2**
		TOTAL	**21**			**21**		

Note: *Subjects under each elective shall be same as those for Regular students (Page 167).*

Curriculum Structure (PS-8)

(For Students opting for Practice School / Industry Internship in the 8th Semester)

Semester VII									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
PC	18CS1T09	Soft Computing	3	1	0	3	1	0
PC	18CS1T10	Computer Graphics	3	0	0	3	0	0
PE	18**2T**	Professional Elective - V	3	0	0	3	0	0
PE	18**2T**	Professional Elective - VI	3	0	0	3	0	0
OE	18**3T**	Open Elective - I	3	0	0	3	0	0
OE	18**3T**	Open Elective - II	3	0	0	3	0	0
PRACTICAL									
PC	18CS1L09	Soft Computing Lab	0	0	2	0	0	1
PJ	18IR6L04	Summer Internship - III	0	0	0	0	0	1
		SUB-TOTAL	**18**	**1**	**2**	**18**	**1**	**2**
		TOTAL	**21**			**21**		

Semester VIII									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
PRACTICAL									
PS	18PS6L08	Practice School / Industry Internship	0	0	0	0	0	16
VV	18VV6L07	Comprehensive Viva	0	0	0	0	0	1
		SUB-TOTAL	**0**	**0**	**0**	**0**	**0**	**17**
		TOTAL	**0**			**17**		

Note: *Subjects under each elective shall be same as those for Regular students (Page 167).*

List of Electives

Code	Elective # and Subjects
	Professional Elective - V
18CS2T25	Advanced Machine Learning
18CS2T46	Internet of Things
18CS2T33	Compiler Design
18CS2T58	Server Side Scripting
	Professional Elective - VI
18CS2T30	Big Data Analytics
18CS2T36	Cryptography & Network Security
18CS2T40	Embedded Systems
18CS2T34	Computational Biology
	Open Elective - I
18EE3T31	[EEE] Electrical Circuits & Safety
18BS3T01	[BSH] Applied Linear Algebra
18BS3T13	[BSH] Project Management
18EC3T41	[ECE] Signals & Systems
18EI3T43	[EIE] Transducers & Measurement Systems
	Open Elective - II
18EE3T32	[EEE] Energy Conversion Devices
18BS3T12	[BSH] Stochastic Processes
18BS3T07	[BSH] Organisational Behaviour
18EC3T28	[ECE] Communication Systems Engineering
18EI3T05	[EIE] Biomedical Instrumentation & Signal Processing
	Open Elective - III
18EE3T40	[EEE] Renewable Energy Systems
18BS3T34	[BSH] Graph Theory
18BS3T44	[BSH] Financial Management
18EC3T36	[ECE] Introduction to Digital Signal Processing
18EI3T37	[EIE] Introduction to VLSI Design
	Open Elective - IV
18EE3T33	[EEE] Energy Studies
18BST18	[BSH] Simulation & Modeling
18BS3T20	[BSH] Entrepreneurship Development
18EC3T21	[ECE] Satellite Communication Systems
18EC3T30	[ECE] Digital Image & Video Processing
18EC3T22	[ECE] Robotics & Robot Applications
18EI3T25	[EIE] Industrial Instrumentation

Note: *Open Electives are choice-based courses offered by other departments as indicated within brackets.*

Type	Code	Soft Computing	L-T-P	Credits	Marks
PC	18CS1T09		3-1-0	4	100

Objectives	The objective of this course is to study non-traditional computing techniques to solve hard real-world problems using artificial neural networks, fuzzy systems and genetic algorithm. Different aspects of hybridization with some case studies will also be discussed.
Pre-Requisites	Knowledge of Linear Algebra, Data Structures, and Algorithm Design is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on problem solving and applications.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Fuzzy Logic**: Basic definition and terminology of fuzzy set, Set theoretic operations, T-norm, T-conorm, Membership function formulation and parameterization, Extension principle, Fuzzy relations, Linguistic variables, Fuzzy if-then rules, Compositional rule of inference, Fuzzy reasoning, Fuzzy inference systems, Mamdani fuzzy models, Defuzzification, Sugeno and Tsukamoto fuzzy models.	**10 Hours**
Module-2	**Genetic Algorithm**: Introduction, Working cycle of a GA, Binary Coded GA, GA-parameter setting, Constraint handling GA, Advantages and disadvantages of GA, Some specialized GA (Real Coded GA).	**8 Hours**
Module-3	**Neural Network - I**: Introduction, Models of a neuron, Network architecture, Knowledge representation; Learning process - Error correction learning, Memory based learning, Hebbian learning, Competitive learning, Boltzmann learning, Learning with and without a teacher; Single layered learning - Least Mean Square algorithm, Perceptron, ADALINE, MADALINE.	**10 Hours**
Module-4	**Neural Network - II**: Multilayer perceptron - Back-propagation algorithm, XOR problem; Self-organizing Maps - Two basic feature mapping models, SOM algorithm, Radial Basis Function Network, Introduction to ART.	**8 Hours**
Module-5	**Hybrid Systems**: Combination of Genetic Algorithms with Fuzzy Logic or Neural Networks, Combination of Neural Network and Fuzzy Logic.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. J. S. R. Jang, C. T. Sun, and E. Mizutani, ***Neuro Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence***, 1st Edition, Pearson Education, 2015.
T2. D. K. Pratihar, ***Soft Computing***, Revised Edition, Narosa Publishing, 2015.
T3. S. Haykin, ***Neural Networks: A Comprehensive Foundation***, 2nd Edition, Pearson Education, 2006.

Reference Books:

R1. T. Munakata, ***Fundamentals of the New Artificial Intelligence: Neural, Evolutionary, Fuzzy and More***, 2nd Edition, Springer, 2014.

R2. F. O. Karray and C. De Silva, ***Soft Computing and Intelligent Systems Design: Theory, Tools and Applications***, 1st Edition, Pearson Education, 2009.

Online Resources:

1. https://cse.iitkgp.ac.in/~dsamanta/courses/sca/resources/slides/GA-01%20Introduction.pdf
2. https://nptel.ac.in/courses/117105084/
3. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/106105173/lec14.pdf
4. https://cse.iitkgp.ac.in/~dsamanta/courses/sca/resources/slides/NN-03%20Training.pdf

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

CO1	Apply fuzzy logic and fuzzy inference system concept to design automation system for real life problems.
CO2	Apply the concepts of genetic algorithm to solve engineering optimization problems.
CO3	Train the Artificial Neural Network for decision making in real life environment.
CO4	Use the concepts of Artificial Neural Network (ANN) to solve real life engineering and societal problems.
CO5	Envisage the need of hybridization, and to develop hybrid models for solving complex problems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2									3	1	2
CO2	3	3	3	2									3	1	2
CO3	3	3	3	2									3	1	2
CO4	3	3	3	2									3	2	3
CO5	3	3	3	1									3	1	3

Type	Code	Computer Graphics	L-T-P	Credits	Marks
PC	18CS1T10		3-0-0	3	100

Objectives	The objective of this course is to study computer modeling of 2D & 3-D objects and efficiently generating photorealistic renderings on color raster graphics devices.
Pre-Requisites	Knowledge of coordinate geometry and matrix operations is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction, Overview of computer graphics, Basic terminologies in graphics, Lookup table, Plotters, Printers, Digitizers, Light pens, Active & passive graphics devices, Raster & random scan displays, CRT basics, Video basics.	**8 Hours**
Module-2	Output Primitives - Points, Lines, Circles and Ellipses as primitives, Scan conversion algorithms for primitives, Fill area primitives including scan-line polygon filling, Inside-outside test, Boundary and flood-fill, Character generation, Line attributes, Area-fill attributes, Character attributers.	**10 Hours**
Module-3	2D and 3D Transformations (translation, rotation, scaling), Matrix representation, Homogeneous coordinates, Composite transformations, Reflection and shearing, Viewing pipeline and coordinates system, Window-to-viewport transformation, Clipping including point clipping, Line clipping (Cohen-Sutherland, Liang-Bersky), Polygon clipping.	**8 Hours**
Module-4	3D display methods, Polygon surfaces, Tables, Equations, Meshes, Curved lines and surfaces, Quadric surfaces, Spline representation, Cubic spline interpolation methods, Bezier curves and surfaces, B-spline curves and surfaces, General (parallel and perspective) projection transformations, Fractal geometry.	**8 Hours**
Module-5	Visible surface detection concepts, Back-face detection, Depth buffer method, Illumination, Light sources, Illumination methods (ambient, diffuse reflection, specular reflection), Color models - properties of light, XYZ, RGB, YIQ and CMY color models, Animation (introduction only).	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. D. Hearn and P. Baker, ***Computer Graphics – C Version***, 2nd Edition, Pearson Education, 2004.
T2. F. S. Hill, ***Computer Graphics using OpenGL***, 2nd Edition, Pearson Education, 2003.

Reference Books:

R1. J. F. Huges, A. V. Dam, M. McGuire, D. F. Sklar, J. D. Foley, S. K. Feiner, and K. Akeley, ***Computer Graphics: Principles and Practice***, 3rd Edition, Addison-Wesley Professional, 2013.

R2. D. Hearn, M. P. Baker and W. Caritthers, ***Computer Graphics with OpenGL***, 4th Edition, Prentice Hall India, 2010.
R3. S. Harrington, ***Computer Graphics - A Programming Approach***, 2nd Edition, Tata McGraw-Hill, 2004.

Online Resources:
1. http://nptel.ac.in/courses/106102065/: by Prof. P. K Kalra, IIT Delhi
2. https://nptel.ac.in/courses/106/106/106106090/: by Prof. S. Das, IIT Madras

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

CO1	Describe the basics of computer graphics and its applications.
CO2	Explore the standard line, circle, and area filling algorithms.
CO3	Design various transformation models in 2D and 3D spaces.
CO4	Apply the design principles to generate curves and mapping using projection.
CO5	Explore hidden lines and surface detection techniques with color models.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	2	1					1	1	1	2	2	1	1
CO2	3	1	2	1			1			2	1	3	3	1	1
CO3	3	2	3	2									1		
CO4	1	1	2			2							2	1	1
CO5	3	2	2	1			1			2		1	1		

Type	Code	Advanced Machine Learning	L-T-P	Credits	Marks
PE	18CS2T25		3-0-0	3	100

Objectives	The objective of the course is to learn the concepts behind regularization of parameters, deep neural networks, probabilistic graphical models, dimensionality reduction etc., and their use to solve related machine learning problems in real world applications.
Pre-Requisites	Knowledge of mathematics and basic machine learning is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Regularization for Deep Learning: Parameter Norm Penalties, Norm Penalities as Constrained Optimization, Regularization and Under-Constrained Problems, Dataset Augmentation, Noise Robustness, Early Stopping, Parameter Tying and Parameter Sharing, Sparse Representations, Bagging and Other Ensemble Methods, Dropout, Adversarial Training. Optimization for Training Deep Models : Challenges in Neural Network Optimization, Basic Algorithms, Parameter Initialization Strategies, Algorithms with Adaptive Learning Rates, Approximate Second-order Methods, Optimization Strategies.	**10 Hours**
Module-2	Convolutional Networks: The Convolution Operation, Motivation, Pooling, convolution and Pooling as an infinitely strong prior, Variants of the Basic Convolution Function, Structured Outputs, Data Types, Efficient convolution Algorithms, Random or Unsupervised Features, The Neuroscientific Basis for Convolutional Networks, Convolutional Networks and the History of Deep Learning, Applications.	**6 Hours**
Module-3	Sequence Modeling : Recurrent and Recursive Nets : Unfolding Computational Graphs, Recurrent Neural Networks, Bidirectional RNNs, Encoder-Decoder Sequence-to-Sequence Architecture, Deep recurrent Networks, Recursive Neural Networks, The Challenge of Long-Term Dependencies, Echo State Networks, Leaky Units and Other Strategies for Multiple Time Scales, The Long Short-Term Memory and Other Gated RNNs, Optimization for Long-Term Dependencies, Applications.	**6 Hours**
Module-4	Graphical models-DIRECTED Graphical models (Bayesian networks), Hidden Markov Models and Markov Random fields. EM algorithm and Gaussian mixture model.	**10 Hours**
Module-5	Review of SVM: Multiclass SVM, Multiple kernels, kernels for texts, strings, and graphs, Applications; Dimensionality Reduction: Orthogonal feature selection, LLE, Auto Encoder, Matrix factorization and applications (image processing, Collaborative filtering).	**10 Hours**
	Total	**42 Hours**

Text Books:

T1. I. Goodfellow, Y. Bengio, and A. Courville, ***Deep Learning***, 1st Edition, The MIT Press, 2016.
T2. S. Marsland, ***Machine Learning: An Algorithmic Perspective***, 1st Edition, CRC Press, 2009.
T3. J. S. Taylor and N. Cristianini, ***Kernel Methods for Pattern Analysis***, 1st Edition, Cambridge University Press, 2004.
T4. A. Geron, ***Hands-on Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems***, 2nd Edition, O'Reilly Media, 2019.

Reference Books:

R1. D. Koller and N. Friedman, ***Probabilistic Graphical Models: Principles and Techniques***, 1st Edition, The MIT Press, 2009.
R2. D. Barber, ***Bayesian Reasoning and Machine Learning***, 1st Edition, Cambridge University Press, 2012.
R3. K. P. Murphy, ***Machine Learning: A Probabilistic Perspective***, 1st Edition, The MIT Press, 2012.
R4. C. M. Bishop, ***Pattern Recognition and Machine Learning***, 1st Edition, Springer, 2006.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105215/: by Prof. P. K. Biswas, IIT Kharagpur
2. http://cs229.stanford.edu/syllabus.html: Notes by Stanford University

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

CO1	Apply knowledge of regularization to improve the performance of deep learning methods.
CO2	Understand the basics of CNN and apply this to solve related problems.
CO3	Understand the basics of RNN and apply this to solve related problems.
CO4	Study the representation, learning and inference of some graphical models.
CO5	Understand an advanced SVM technique and some algorithms for feature selection and extraction.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2		1						1	3	2	3
CO2	3	3	2	2		1						1	3	2	3
CO3	3	3	2	2		1						1	3	2	3
CO4	3	3	2	2		1						1	3	1	3
CO5	3	3	2	2		1						1	3	1	3

Type	Code	Internet of Things	L-T-P	Credits	Marks
PE	18CS2T46		3-0-0	3	100

Objectives	The objective of this course is to study the concepts, technologies, design principles, challenges, and case-studies of Internet of Things to enable them to build IoT applications for the real world.
Pre-Requisites	Basic knowledge of computer networks, sensor network, micro-processor and micro-controllers is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies, and latest trends.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to IoT: Definition, Characteristic, Components of IoT, Design of IoT systems, Technology and systems implementing IoT, Levels of IoT, Sensors, Actuators, Power Supply.	**8 Hours**
Module-2	IoT Network Model: OSI reference model, Layers in IoT; Protocols: MAC based Protocols, IP based Protocols, Simple Network Management Protocol (SNMP), NetConf, Yang.	**10 Hours**
Module-3	M2M: IoT vs. M2M, Software Defined Networking, Network Function Virtualization; IoT Platform Design: IoT Design Methodology, Resource Management in IoT, Data Synchronization.	**9 Hours**
Module-4	Devices: Zigbee, Bluetooth, Wi-fi, RFID, Cloud Computing, Big Data.	**9 Hours**
Module-5	Case Studies: IoT in Smart Home, Smart Grid, Agriculture, Healthcare, Smart Industry, Environment, Smart Cities.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. A. Bahga and V. Madisetti, ***Internet of Things: A Hands-on Approach***, 1st Edition, University Press, 2018.
T2. O. Hersent, D. Boswarthick, and O. Elloumi, ***The Internet of Things: Key Applications and Protocols***, Student Edition, John Wiley & Sons, 2016.

Reference Books:

R1. D. Uckelmann, M. Harrison, and F. Michahelles, ***Architecting the Internet of Things***, 1st Edition, Springer, 2011.
R2. R. Buyya and A. V. Dastjerdi, ***Internet of Things: Principles and Paradigms***, 1st Edition, Morgan Kaufmann, 2016.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105166/: by Prof. S. Misra, IIT Kharagpur
2. https://nptel.ac.in/courses/108/108/108108098/: by Prof. T. V. Prabhakar, IISc Bangalore

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

CO1	Explain basic concepts of IoT, its architecture and system design.
CO2	Visualize communication between sensors and systems using various protocols and network models.
CO3	Differentiate between IoT & M2M and design IoT platforms with data and resource management.
CO4	Describe advanced IoT concepts applied in various devices.
CO5	Envisage real-time applications of IoT for designing solutions to real-world problems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		1			1		1				2	3	1	3
CO2	2		3			2		2				2	2	1	3
CO3	3		3			2		2				2	2	1	3
CO4	2		3			2		2				2	2	1	2
CO5	3		3			2		2				3	3	1	3

Type	Code	Compiler Design	L-T-P	Credits	Marks
PE	18CS2T33		3-0-0	3	100

Objectives	The objective of this course is to study the components of compiler and the principles involved in design of compilers for modern computer languages.
Pre-Requisites	Knowledge of formal language & automata theory and proficiency in any programming language is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on algorithms, problem solving, and examples.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Overview of Compiler, Introduction to Lexical Analysis, Regular Language, Regular Expression (RE), Regular Definitions, Finite State Automata (DFA, NFA), RE to DFA conversion, Transition Diagram (TD), Lexical Analyzer (LA), LA Implementation from TD, LEX tool as LA Generator, LEX examples.	**9 Hours**
Module-2	Context Free Grammar (CFG), Ambiguity in CFG, Ambiguity removal, Elimination of Left Recursion, Elimination of non-determinism, Introduction to Parser, Top-Down Parsing, LL(1), Bottom-Up parsing, Construction of LR(0), SLR(1) parsing table, Construction of CLR(1), LALR(1) parsing table, Conflicts in LR, SLR, CLR, LALR parsing, LR parsing algorithm with example.	**10 Hours**
Module-3	Operator Precedence Parser, Error Reporting and Recovery, Syntax Directed Translation (SDT), S-attribute SDT, S-attribute SDT examples, YACC, Symbol Table.	**8 Hours**
Module-4	Intermediate Code Generation, Type of Intermediate Code, Intermediate code for various programming construct, Run-Time Environment, Run-Time Support, parameter passing methods, Activation Record, Variable storage and offset computation, Accessing Global Variable & allocation of Activation Record.	**8 Hours**
Module-5	Scope (Static, dynamic), Machine Code Generation, Different Schemes of Code Generation, Code Optimization, peephole optimization (Redundant Instruction Elimination, Flow of control optimization, Eliminating unreachable codes), Local Optimization, Control Flow Graph, DAG, Local common sub expression elimination (Value Numbering in Basic Blocks).	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. A. V. Aho, M. S. Lam, R. Sethi, and J. D. Ullman, ***Compilers: Principles, Techniques and Tools***, 2nd Edition, Pearson Education, 2009.

Reference Books:

R1. K. D. Cooper and L. Torczon, ***Engineering a Compiler***, 2nd Edition, Morgan Kaufmann, 2011.

R2. A. I. Holub, ***Compiler Design in C***, 2nd Edition, Prentice Hall of India, 2002.

Online Resources:

1. https://nptel.ac.in/courses/128/106/128106009/: from IIT Madras
2. https://nptel.ac.in/courses/106/105/106105190/: by Prof. S. Chattopadhyay, IIT Kharagpur
3. https://nptel.ac.in/courses/106/104/106104123/: by Prof. S. K. Aggarwal, IIT Kanpur
4. https://nptel.ac.in/courses/106/108/106108113/: by Prof. Y. N. Srikanth, IISc Bangalore
5. https://nptel.ac.in/courses/106/104/106104072/: by Prof. S. K. Aggarwal, IIT Kanpur

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

CO1	Identify phases of a compiler, process of designing lexical analyzer, and apply LEX tool.
CO2	Construct parsing tables and implement parser using BISON tool.
CO3	Understand use of symbol table and design SDT as semantic analyzer for a language.
CO4	Generate intermediate code using lexical analyzer, parser and semantic analyzer.
CO5	Translate intermediate code to machine code, handle run-time environment, and apply code optimization techniques.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2								3		2
CO2	3	3	2	2	2								3		2
CO3	3	2	2	2									3		2
CO4	3	3	2	2									3		3
CO5	3	3	2	2									3		2

Type	Code	Server Side Scripting	L-T-P	Credits	Marks
PE	18CS2T58		3-0-0	3	100

Objectives	The objective of this course is to introduce various server side scripting technologies and their application for developing & hosting small to large scale web-based applications.
Pre-Requisites	Knowledge of internet technologies and client side scripting languages like HTML, CSS, and Java Script is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on solution design, programming, and examples.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Web Applications: Architecture, Client-side script vs. Server-side script, Web servers (Apache Tomcat/Web Logic); Hosting Web Applications: Cloud hosting, AWS server creation, Hosting in AWS server (with example), Other Hosting Environments; JQuery and Bootstrap 4: JQuery Syntax, Effects, HTML, Ajax, Bootstrap 4 Containers, Grid System, Dropdown, Navigation Bar, Forms.	**9 Hours**
Module-2	Java Server Pages (JSP): Advantages of JSP over Servlet, Lifecycle of a JSP page, JSP API, Scriptlet tag, Implicit Objects, Directives, Exception Handling, Action Tags, Expression Language (EL); Advanced Features of JSP: Session Tracking, MVC, JSTL (JSP Standard Tag Library), Custom Tags, CRUD operations; JSP Sample Code: Pagination, Registration Form, File Uploading.	**9 Hours**
Module-3	Introduction to PHP: Syntax, Variables, Data Types, Loops, Functions, Arrays, Global Variables (Superglobals); PHP Form Handling: Form Validation, Required Fields, Validate E-mail and URL; PHP & XML: XML Parsers, SimpleXML Parser, Get Node/Attribute Values, Expat Parser, XML DOM Parser.	**8 Hours**
Module-4	Advanced PHP: Include Files, File Handling, Cookies, Sessions, JSON, Filters; PHP MySQL: Connecting to MySQL, Insert Data, Prepared Statements, Select Data, Delete Data, Update Data; PHP AJAX: Introduction, AJAX and MySQL, AJAX and XML, Live Search, Poll.	**8 Hours**
Module-5	Node.js: Introduction, Module, HTTP Module, File System Module, URL Module, NPM, Events, Sending an Email; Node.js & MySQL: Create database, Create tables, Insert, Select, Update, Delete, Limit, Join; Node.js & MangoDB: Create Collection, Insert, Find, Query, Sort, Update, Delete, Drop Collection, Limit, Join.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Keogh, ***J2EE: The complete Reference***, 11th Edition, McGraw-Hill Education, 2017.

T2. E. Brown, ***Web Development with Node and Express: Leveraging the JavaScript Stack***, 2nd Edition, O'Reilly Media, 2019.

Reference Books:

R1. S. K. Patel, ***Developing Responsive Web Applications with AJAX and jQuery***, 1st Edition, Packt Publishing, 2014.
R2. R. Nixon, ***Learning PHP, MySQL, JavaScript, CSS & HTML5: A Step-by-Step Guide to Creating Dynamic Websites***, 3rd Edition, O'Reilly Media, 2014.

Online Resources:

1. https://www.w3schools.com/jquery/default.asp
2. https://www.w3schools.com/bootstrap4/default.asp
3. https://www.tutorialspoint.com/php/index.htm
4. https://www.w3schools.com/nodejs/default.asp

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

CO1	Distinguish between client side and server side scripts concepts and will have the knowledge to create server side web page development.
CO2	Design web applications using JSP technology.
CO3	Design and develop small to complex web applications using PHP and MySQL as back-end database.
CO4	Develop complete mail application using PHP and Node.js scripts.
CO5	Create large scale application using Node.js, Ajax and MangoDB concepts.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2									1	2	1	2
CO2	3	3	2		2							1	3	1	2
CO3	2	3	2		2							1	3	1	2
CO4	2	3	2	1	2							1	2	1	2
CO5	2	2	2	1	2							1	2	1	3

Type	Code	Big Data Analytics	L-T-P	Credits	Marks
PE	18CS2T30		3-0-0	3	100

Objectives	The objective of the course is to study different techniques to find similar items, mining data streams, link analysis, clustering techniques, recommendation systems, and collaborative filtering used for Big Data, along with the concepts of batch processing, Hadoop, MapReduce & Spark.
Pre-Requisites	Knowledge of basics of data mining & algorithm design is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Big Data, Data Management for Big Data, Data Exploration and Reproducibility, Data Quality; Introduction to Map Reduce, Map Reduce algorithm, patterns & relations, Parallel databases vs. Map Reduce, Storage solutions.	**7 Hours**
Module-2	Big Data Algorithms-I: Nearest Neighbor Search, Shingling of Documents, Similarity Preserving Summaries of Sets, Locality Sensitive Hashing for Documents, Distance Measures, Theory of Locality Sensitive Functions, LSH Families for High Degree of Similarities.	**9 Hours**
Module-3	Big Data Algorithms-II: Streaming Data Models, Sampling Data in a Stream, Filtering Streams, Counting Distinct Elements in a Stream, Estimating Moments, Counting Ones in Window, Page Rank, Efficient Computation of Page Rank, Topic Sensitive Page Rank.	**9 Hours**
Module-4	Big Data Algorithms-III: Clustering Techniques - BFR Algorithm, CURE Algorithm, Clustering in Non-Euclidean Space, Clustering for Streams and Parallelism; Matrix Factorization, Recommendation Systems and Collaborative Filtering.	**9 Hours**
Module-5	Introductions to Spark, Hadoop, Hive, Pig-Latin, Large Scale Visualization.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Leskovec, A. Rajaraman, and J. D. Ullman, ***Mining of Massive Datasets***, 2nd Edition, Cambridge University Press, 2014.
T2. J. Bell, ***Machine Learning for Big Data: Hands-On for Developers and Technical Professionals***, Wiley, 2014.

Reference Books:

R1. J. Han, M. Kamber, and J. Pei, ***Data Mining Concepts and Techniques***, 3rd Edition, Morgan Kaufman Publications, 2011.
R2. T. M. Mitchell, ***Machine Learning***, 1st Edition, McGraw-Hill Education, 2017.

Online Resources:

1. https://nptel.ac.in/courses/106/106/106106142/: by Prof. J. Augustine, IIT Madras
2. https://nptel.ac.in/courses/106/104/106104189/: by Dr. R. Misra, IIT Patna
3. http://www.mmds.org: Material on Mining of Massive Data Sets
4. http://lintool.github.com/MapReduceAlgorithms/index.html

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

CO1	Explain the concepts of Big Data and Map Reduce techniques.
CO2	Apply different tools and techniques used for finding similar items.
CO3	Demonstrate application of algorithms for analysis of streaming data and link analysis.
CO4	Apply different techniques for recommendation systems & collaborative filtering and compare different clustering techniques to apply them for large dataset.
CO5	Explore the concepts of Hadoop, MapReduce, Spark and apply them to implement big data algorithms.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	1							1	3	1	1
CO2	3	3	3	2	1							1	3	1	2
CO3	3	3	3	2	1							1	3	1	2
CO4	3	3	3	2	1							1	3	1	2
CO5	1	1	1	2	3							1	3	1	2

Type	Code	Cryptography & Network Security	L-T-P	Credits	Marks
PE	18CS2T36		3-0-0	3	100

Objectives	The objective of this course is to introduce different security goals, services & mechanisms with primary focus on various cryptography techniques used to protect from security threats in computer networks and data communications.
Pre-Requisites	Knowledge on computer networks and engineering mathematics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on problem solving and examples.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Computer Security Concepts, Security Attacks, Security Services and Mechanisms, Symmetric Cipher model, Cryptography & Cryptanalysis, Substitution Techniques: Caesar cipher, Monoalphabetic cipher, Playfair cipher, Hill Cipher, Polyalphabetic ciphers: Vignere cipher, Vernam cipher, Transposition cipher.	**8 Hours**
Module-2	Integer and Modular Arithmetic, Euclidean and Extended Euclidean Algorithms, Concept of groups, rings, and fields, Difference between GF(p) and GF(2^m), Block cipher principles, Data Encryption Standard (DES), Advanced Encryption Standard (AES).	**9 Hours**
Module-3	Fermat's and Euler's Theorems, Chinese Remainder Theorem, Integer Factorization, Discrete Logarithms; Public Key Cryptography - RSA, ElGamal, Diffie-Hellman Key Exchange; Elliptic Curve Cryptography - Introduction to elliptic curve, arithmetic, application.	**9 Hours**
Module-4	Message Integrity and Authentication; Cryptographic Hash Functions: MD5, SHA family, Digital Signature and applications - ElGamal.	**7 Hours**
Module-5	Key Distribution, Certificate Authority, X.509, Kerberos, E-mail security: PGP, S/MIME, Security at the Transport Layer: SSL/TLS, Security at Network Layer: IPSec, Malicious Software, Firewall, Intrusion Detection.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. W. Stallings, ***Cryptography and Network Security: Principle and Practice***, 7th Edition, Pearson Education, 2017.

Reference Books:

R1. B. A. Forouzan and D. Mukhopadhaya, ***Cryptography and Network Security***, 2nd Edition, McGraw-Hill Education, 2010.
R2. C. P. Pfleeger, S. L. Pfleeger, and J. Margulies, ***Security in Computing***, 5th Edition, Prentice Hall India, 2015.
R3. C. Kaufman, R. Perlman, and M. Speciner, ***Network Security: Private Communication in a Public World***, 2nd Edition, Prentice Hall India, 2002.

R4. A. J. Menezes, P. C. van Oorschot, and S. A. Vanstone, ***Handbook of Applied Cryptography***, CRC Press, 1996.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105031/: by Dr. D. Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/106/105/106105162/: by Prof. S. Mukhopadhyay, IIT Kharagpur
3. https://nptel.ac.in/courses/106/106/106106221/: by Prof. A. Choudhury, IIIT Bangalore
4. https://www.cryptool.org/en/

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

CO1	Identify security objectives & threats and enumerate necessary services & mechanisms for effective counter measures.
CO2	Explain the mathematical foundation of cryptography through modular arithmetic, linear algebra, number theory, factorization and discrete logarithm.
CO3	Analyze the performance of traditional symmetric key cryptography techniques and modern symmetric key ciphers like DES and AES.
CO4	Apply public key cryptography and Hash algorithms in encryption, data integrity, authentication, digital signature, and key exchange.
CO5	Apply cryptography techniques in various network security protocols like SSL, TLS, PGP, S/MIME, and IPsec.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1									3		3
CO2	3	3	1	1									3		3
CO3	3	3	3	2		2							3		2
CO4	3	3	3	2		2							3		3
CO5	1	3	3	3		2							3		3

Type	Code	Embedded Systems	L-T-P	Credits	Marks
PE	18CS2T40		3-0-0	3	100

Objectives	The objective of this course is to study the concepts & architecture of embedded systems including ARM architecture, real-time operating systems, hardware-software co-simulation, hardware-software partitioning, and low power embedded systems design.
Pre-Requisites	Knowledge of operating systems, computer organization and architecture is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies, and latest trends.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Hardware Concepts: Embedded system, Applications & characteristics, Overview of processors and hardware units in embedded system, Embedded software in a system, Design metrics, Embedded system design flow.	**8 Hours**
Module-2	ARM: ARM microcontroller, History, ARM pipeline, Instruction Set Architecture (ISA), THUMB instructions.	**8 Hours**
Module-3	Interfacing: Serial Peripheral Interface (SPI), IIC, RS-232C, RS-422, RS-485, USB, USB interface, USB connectors, IrDA, CAN, Bluetooth, ISA, PCI.	**8 Hours**
Module-4	Real-Time Operating systems: Important concepts of Real-time task scheduling, Types of real-time tasks and their characteristics, Task scheduling, Clock-driven scheduling, Hybrid scheduler, Event-driven scheduling, EDF, RMA, Resource sharing using PIP, HLP and PCP, Features of real-time operating system, Commercial RTOSs like PSOS, VRTX, Lynx, VxWorks, Windows CE.	**10 Hours**
Module-5	Modeling Techniques: Software and programming concepts, Processor selection for an embedded system, State chart, SDL, Petri-Nets, UML, Hardware-software partitioning: K-L partitioning, Low power embedded system design: Dynamic power dissipation, Static power dissipation, Power reduction techniques such as algorithmic power minimization, control logic power minimization, System level power management.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. F. Vahid and T. Givargis, ***Embedded Systems Design: : A Unified Hardware / Software Introduction***, Student Edition, Wiley India, 2002.
T2. S. Chattopadhyay, ***Embedded System Design***, 2nd Edition, Prentice Hall India, 2013.
T3. R. Mall, ***Real-Time Systems***, 2nd Edition, Pearson Education, 2010.

Reference Books:

R1. P. Marwedel, ***Embedded System Design***, 1st Edition, Springer, 2006.

R2. R. Kamal, ***Embedded Systems: Architecture, Programming and Design***, 2nd Edition, McGraw-Hill Education, 2008.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105159/: by Prof. A. Basu, IIT Kharagpur
2. https://nptel.ac.in/courses/108/105/108105057/: by Prof. R. Mall, Prof. A. Patra, and Prof. A. Routray, IIT Kharagpur
3. https://nptel.ac.in/courses/108/102/108102045/: by Prof. S. Chaudhary, IIT Delhi
4. https://nptel.ac.in/courses/106/105/106105193/: by Prof. I. Sengupta and Prof. K. Datta, IIT Kharagpur

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

CO1	Describe the architecture, components, hardware & software of embedded systems.
CO2	Explain the ARM architecture, its instruction set, and features.
CO3	Explain & analyze device drivers and their interfacing in embedded systems.
CO4	Visualize real-time operating systems and analyze task-scheduling algorithms.
CO5	Model embedded systems using various techniques and minimize power consumption.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2		2								3		3
CO2	2	2	2		2								3		3
CO3	3	2	2	2	3								2		2
CO4	2	3	2	2	3								3		2
CO5	3	1	3	2	2								3		2

Type	Code	Computational Biology	L-T-P	Credits	Marks
PE	18CS2T34		3-0-0	3	100

Objectives	The objective of this course is to study applications of algorithms and other computer-based techniques to solve problems related to biological sciences such as molecular biology, DNA sequencing, searching and matching etc.
Pre-Requisites	Knowledge on biology, algorithms and machine learning is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on algorithms & problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Computational Biology and its applications, Molecular Biology primer, Biological Sequences, Biological Systems, Introduction to Biological Databases, Introduction to Suffix Trees, A naïve algorithm to build a suffix tree, Ukkonen's linear-time suffix tree algorithm, Application of suffix trees.	**8 Hours**
Module-2	DNA Sequence Analysis, Edit Distance, Edit Transcript, LCS, Pair wise Alignment, Score of alignment, Global Alignment and Applications, Needleman-Wunsch Algorithm and Analysis, Pair wise Local Alignment, Alignment Score and Applications, Smith-Waterman Local Alignment Algorithm and Analysis, Gap Penalties.	**8 Hours**
Module-3	Exact Pattern Matching: KMP Algorithm, Keyword Trees, Aho-Corasick Algorithm; Clustering Basics: Hierarchical Clustering; Multiple Sequence Alignment: CLUSTAL, Center-Based Clustering, Clustering via Cliques.	**9 Hours**
Module-4	Graph Algorithms: SBH, SBH as Hamiltonian Path Problem, SBH as Eulerian Path Problem, Fragment Assembly in DNA Sequencing, Protein Sequencing and Identification, The Peptide Sequencing Problem, Spectrum Graph.	**8 Hours**
Module-5	Evolutionary Trees and Phylogeny: Evolutionary Trees and Ultrametics, Additive Distance Trees, Perfect Phylogeny Problem, Small Parsimony Problem. Hidden Markov Models, Forward and Backward Algorithms, Viterbi Algorithm and their applications.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. N. C. Jones and P. A. Pevzner, ***An Introduction to Bioinformatics Algorithms***, 1st Edition, MIT Press, 2005.
T2. D. Gusfields, ***Algorithms On Strings, Trees, and Sequences***, 1st Edition, Cambridge University Press, 1997.

Reference Books:

R1. N. Gautham, ***Bioinformatics: Databases and Algorithms***, Narosa Publishing, 2006.
R2. A. M. Lesk, ***Introduction to Bioinformatics***, 5th Edition, Oxford University Press, 2019.
R3. T. K. Attwood and D. J. Parry-Smith, ***Introduction to Bioinformatics***, Pearson Education, 2001.

Online Resources:

1. https://nptel.ac.in/courses/102106065/: by Prof. M. M. Gromiha, IIT Madras
2. https://www.coursera.org/lecture/algorithms-greedy/application-sequence-alignment-ekVkk
3. https://www.coursera.org/lecture/comparing-genomes/multiple-sequence-alignment-jNof9

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

CO1	Analyze and model Bio-molecules in terms of computational problems.
CO2	Apply sequence analysis methods to curate new biological sequences.
CO3	Use computational methods for finding the conserved regions in biological sequences and their usages.
CO4	Model bio-molecular interactions using graphs and understand the behavior of interactions.
CO5	Investigate ancestral relationship of different species using statistical analysis.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1								2	3	1	1
CO2	3	3	3	3								2	3	1	1
CO3	3	3	3	3								2	3	1	1
CO4	3	3	3	3								2	3	1	1
CO5	3	3	3	3								2	3	1	1

Type	Code	Electrical Circuits & Safety	L-T-P	Credits	Marks
OE	18EE3T31		3-0-0	3	100

Objectives	The objective of the subject is to learn the concepts of electrical networks, various safety measures & Indian electrical safety standards.
Pre-Requisites	Knowledge on basic electrical engineering is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies and standards.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Open circuit, Closed circuit, Short circuits, Definitions of node, branch, loop, mesh; Kirchhoff's Laws: Kirchhoff's Voltage and Current Laws (KVL and KCL); Mesh and Nodal analysis of networks, Electrostatic induction, Electric flux, Flux density, Electric field intensity; Capacitance – Effects of dielectrics, Dielectric constant units; Types of capacitors, Capacitors in series and parallel; Energy stored in a capacitor.	**8 Hours**
Module-2	Electromagnetic Induction; Faraday's law, Lenz's law, Fleming's right hand rule for generators, Fleming's left-hand rule for Motors; Statically and dynamically induced EMF; Inductance: Self and Mutual inductance, Types of Inductor; Energy stored in magnetic field.	**6 Hours**
Module-3	Primary and secondary hazards - arc, blast, shocks, Causes and effects, Safety equipment, Flash and thermal protection, Head and eye protection, Rubber insulating equipment, Hot sticks, Insulated tools, Barriers and signs, Safety tags, Locking devices, Voltage measuring instruments, Proximity and contact testers, Safety electrical one line diagram, Electrician's safety kit; Importance of earthing in various electrical circuits, Types of earthing.	**12 Hours**
Module-4	Electrical safety programme structure, Development, Company safety team, Safety policy programme implementation, Employee electrical safety teams, Safety meetings, Safety audit accident prevention, First aid, Rescue techniques, Accident investigation.	**8 Hours**
Module-5	Safety related case for electrical maintenance, Reliability centered maintenance (RCM), Eight step maintenance programme, Frequency of maintenance, Maintenance requirement for specific equipment and location, Regulatory bodies, National electrical safety code, Standard for electrical safety in work place, Occupational safety and health administration standards, Indian Electricity Acts related to Electrical Safety.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. T. Singh, ***Fundamentals of Electrical Engineering***, 1st Edition, S. K. Kataria & Sons, 2012.
T2. J. Cadick, M. Capelli-Schellpfeffer, D. Neitzel, and A. Winfield, ***Electrical Safety Handbook***, 5th Edition, McGraw-Hill Education, 2019.

Reference Books:

R1. B. L.Thereja, ***Electrical Technology Vol-1***, 6th Edition, S. Chand & Co., 2011.
R2. A. J. Maxwell, ***Electrical Safety: A Guide to the Causes and Prevention of Electric Hazards***, The Institution of Electric Engineers (IET), 1994.
R3. R. A. Jones and J. G. Jones, ***Electrical Safety in the Workplace***, Jones & Bartlett Learning, 2000.

Online Resources:

1. https://nptel.ac.in/courses/108102042/: by Prof. S. C. Dutta Roy, IIT Delhi
2. https://nptel.ac.in/courses/108/104/108104139/: by Prof. A. Sharma, IIT Kanpur

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

CO1	Comprehend the basic concepts of DC circuits and apply different laws for circuit analysis.
CO2	Explain the basic concepts of AC circuits and different electromagnetic principle.
CO3	Troubleshoot and justify requirements of earthing for electrical safety.
CO4	Analyze the safety policies & audit and take necessary steps during accidents.
CO5	Understand electrical maintenance and Indian electricity act related to safety.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2		1						2	3	1	1
CO2	3	3	2	2		2						2	3	1	
CO3	3	3	2	2		3						2	3		1
CO4	3	3	3	2		3						2	2	2	1
CO5	3	2	2	2		3						2	3	1	1

Type	Code	Applied Linear Algebra	L-T-P	Credits	Marks
OE	18BS3T01		3-0-0	3	100

Objectives	The objectives of this course is to gain mathematical maturity by equipping the students to handle computation with matrices, difference equation and similarity transformation for various engineering applications.
Pre-Requisites	Knowledge of complex numbers, matrix algebra, and vector space is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Geometry of Linear Equations, Gauss Elimination, Concept of Matrices with Applications, Vector Spaces and Subspaces, Echelon Form, Solution in Matrix Method, L.I, Basis & Dimension, Four Fundamental Subspaces, Linear Transformations.	**9 Hours**
Module-2	Orthogonal Vectors & Subspaces, Cosines & Projections onto Lines, Projections & Least Squares, Orthogonal Bases and Gram-Schmidt Process.	**8 Hours**
Module-3	Introduction & Properties of Determinants, Formulas for Determinant, Applications of Determinants, Introduction to Eigenvalues & Eigenvectors, Diagonalization of Matrix, Difference Equations, Complex Matrices, Similarity Transformations.	**8 Hours**
Module-4	Maxima, Minima & Saddle Points, Tests for Positive Definiteness, Singular Value Decomposition, Minimum Principles.	**8 Hours**
Module-5	Introduction to Computations with Matrices, Matrix Norm & Condition Number, Computation of Eigenvalues, Iterative Methods.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. G. Strang, ***Linear Algebra and Its Applications***, 4th Edition, Cengage Learning, 2007.

Reference Books:

R1. G. Strang, ***Introduction to Linear Algebra***, 3rd Edition, Wellesley-Cambridge, 2003.

Online Resources:

1. https://nptel.ac.in/courses/111/106/111106051/: by Dr. K. C. Sivakumar, IIT Madras
2. https://nptel.ac.in/courses/111/102/111102011/: by Dr. R. K. Sharma and Dr. W. Shukla, IIT Delhi
3. https://nptel.ac.in/courses/111/108/111108066/: by Prof. V. Rao, IISc Bangalore
4. https://nptel.ac.in/courses/111/107/111107106/: by Prof. P. N. Agrawal and Prof. D. N. Pandey, IIT Roorkee

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

CO1	Explain and apply matrix methods for solving a system of linear equations.
CO2	Describe orthogonal & projection in vector space and apply it to least square solution.
CO3	Identify and apply Eigen values and Eigen vectors to diagonalization.
CO4	Explain and apply Singular Value Decomposition and to obtain pseudo inverse of a matrix.
CO5	Develop algorithms and write programs to solve linear algebra problems on computers.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	2								2	1	1
CO2	3	2	2	3	2								2	1	1
CO3	3	3	2	2	2								2	1	1
CO4	3	3	3	3	3								2	1	1
CO5	3	3	3	3	3								2	1	1

Type	Code	Project Management	L-T-P	Credits	Marks
OE	18BS3T13		3-0-0	3	100

Objectives	The objective of this course is to study the fundamental tools and behavioral skills necessary to successfully launch, lead, and realize benefits, develop the skills for planning and controlling, and understanding key factors to drive successful project outcomes.
Pre-Requisites	General knowledge of any organization and its operations is sufficient.
Teaching Scheme	Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with real-life examples.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Project Systems Management: a life cycle approach, project characteristics; Project life cycle phases - conception, definition, planning and organizing, implementation, clean up; Project feasibility analysis - market, technical, financial; The project manager: roles & responsibilities, team building and conflict management; Tools and techniques for project management; Environmental impact analysis of a project.	**9 Hours**
Module-2	Commonly used techniques for Project Management, Network techniques - PERT, CPM and GERT; Project appraisal criteria - NPV, IRR; Pay back period, sensitivity analysis; Line of Balance (LOB), Accounting for risk, uncertainty and fuzziness. Time cost trade-offs and crashing procedures; Multi project planning & scheduling with limited resources; Multi objective, fuzzy and stochastic based formulations in a project environment.	**9 Hours**
Module-3	Project Resource Management: Allocation, Leveling and Smoothing methods; Multi project and multi resource, multi-mode scheduling under various constraints - limited resources, limited budget, non-split, start/end lag; Application of Heuristics.	**8 Hours**
Module-4	Cost Benefit Analysis: Cost benefit analysis – projects procurement process, life cycle costing, project cost reduction methods, project stores; Project Cost: Dynamics of project cost, Estimation of capital cost, Estimating operating costs, Forecasting income, Financial sources, Role of development financial institutions; Social cost benefit analysis.	**8 Hours**
Module-5	Planning, Monitoring and Control: Design of monitoring system, Computerized PMIS (Project Management Information System); Funds planning, performance budgeting and control; Project materials management; Pricing, estimating, and Contract Administration & Management, Building & Bid evaluation and analysis.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. R. Paneerselvam and P. Senthilkumar, ***Project Management***, 1st Edition, PHI Learning, 2009.

T2. B. Punmia and K. Khandelwal, ***Project Planning and Control with PERT and CPM***, 4th Edition, Laxmi Publications, 2006.

Reference Books:

R1. P. Chandra, ***Projects Planning, Analysis, Selection, Financing, Implementation and Review***, 9th Edition, McGraw Hill Education, 2019.
R2. C. Gray, E. Larson, and G. Desai, ***Project Management The Managerial Process***, 7th Edition, McGraw Hill, 2013.

Online Resources:

1. https://nptel.ac.in/courses/110/104/110104073/: by Prof. R. Sengupta, IIT Kanpur
2. https://nptel.ac.in/courses/110/107/110107081/: by Prof. S. K. Gupta & Prof. M. K. Barua, IIT Roorkee

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

CO1	Describe the fundamental project management tools and behavioral skills.
CO2	Explain the basic concept of various network techniques for project management.
CO3	Optimally utilize the resources for successful completion of a project.
CO4	Preform cost-benefit analysis of a project considering various factors involved.
CO5	Plan, monitor, control, and administer projects using computerized PMIS tools.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1		1	2			1	1	1			3	1	1		1
CO2	1	1			2	1					3	1	1	1	1
CO3	1	2	2		3	1					3		1	1	1
CO4	1	2	2		2						3	1	1	2	1
CO5	2	2	1		1						3	1	1	1	1

Type	Code	Signals & Systems	L-T-P	Credits	Marks
OE	18EC3T41		3-0-0	3	100

Objectives	The objective of this course is to study the presentation, stability, causality, sampling, and reconstruction of various signals & systems in time & spectrum domains.
Pre-Requisites	Fundamental knowledge of basic mathematics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Signals**: Introduction, Classification: continuous/ discrete-time, commonly used continuous-time signals and discrete-time Signals, Analog/ digital signal, Periodic/ aperiodic, Even/ odd, Energy/ power, Deterministic/ random, Operation on Continuous-time and Discrete time signals: Addition, Multiplication, Differentiation/Difference, Integration/Accumulation, Shifting, Scaling, Folding and Convolution (graphical and analytical), Correlation of Discrete-Time signals & its properties.	**8 Hours**
Module-2	**System and LTI/LSI System**: Introduction, Classification for both continuous time and discrete time - Linear/ Non-linear, Time varying/ time invariant, Causal/ non-causal, Dynamic/ static, Stable/ unstable and Invertible/ Non-invertible, Continuous time and Discrete time LSI system, System representation through differential equations and difference equations, Response of LSI system and convolution Integral/convolution Sum, Characterization of causality and stability of linear shift invariant(LSI).	**8 Hours**
Module-3	**Analysis by Fourier series and Fourier Transform**: Orthogonal and Ortho-normal signal set, Fourier series, convergence of the Fourier series, Trigonometric Fourier series and exponential Fourier series, Continuous time Fourier Transform, convergence of the Fourier transform, Fourier transform of some useful signals, properties of the Fourier transform, the notion of a frequency response and its relation to the impulse response, Parseval's theorem: Energy spectral density, Power spectral density.	**9 Hours**
Module-4	**Analysis by Laplace Transform**: Introduction, Region of Convergence for Laplace transform, and properties of ROC, Laplace transform of some useful signals, properties of the Laplace transform, the inverse Laplace transform and Unilateral Laplace Transform and their properties, Initial value and final value theorem, solution of differential equation using Laplace transform.	**9 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	**Sampling and Reconstruction**: Discrete-time system analysis using the Z-transform, The Sampling Theorem and its implications - Spectra of sampled signals; Reconstruction: ideal interpolator, Aliasing and its effects, Mapping from S-plane to Z-plane, Z-transform, the region of Convergence, Z- transform of some useful sequences, properties of Z-transform, Inverse Z-transform.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, ***Signals and Systems***, 2nd Edition, Prentice Hall India, 1992.
T2. S. Haykin and B. V. Veen, ***Signals and Systems***, 2nd Edition, John Wiley & Sons, 2002.
T3. B. P. Lathi, ***Principles of Signal Processing and Linear Systems***, 2nd Edition, Oxford University Press, 2009.

Reference Books:

R1. A. Ambardar, ***Analog and Digital Signal Processing***, 2nd Edition, Brooks/Cole Publishing, 1999.
R2. H. P. Hsu, ***Signal and System - Schaum's Outlines***, 2nd Edition, McGraw Hill, 2011.
R3. M. J. Roberts, ***Signals and Systems - Analysis using Transform methods and MATLAB***, 2nd Edition, McGraw Hill, 2003.
R4. A. N. Kani, ***Signals and System***, 2nd Edition, McGraw Hill Education, 2010.

Online Resources:

1. https://nptel.ac.in/courses/117104074/: by Prof. K.S. Venkatesh, IIT Kanpur
2. https://nptel.ac.in/courses/108105065/: by Prof. T.K. Basu, IIT Kharagpur
3. https://nptel.ac.in/courses/108104100/: by Prof. A. K. Jagannatham, IIT Kanpur
4. https://nptel.ac.in/courses/108105059/: by Prof. S. Mukhopadhyay, IIT Kharagpur
5. https://ocw.mit.edu/resources/res-6-007-signals-and-systems-spring-2011/lecture-notes/
6. https://engineering.purdue.edu/~mikedz/ee301/ee301.html
7. https://stanford.edu/~boyd/ee102/

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

CO1	Describe different types of signals and systems.
CO2	Analyze various types of LSI systems responses.
CO3	Represent continuous and discrete systems in time & frequency domains using different transforms.
CO4	Investigate the system stability and causality using Laplace Transform and Z-Transform.
CO5	Perform sampling and reconstruction of a given signal.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Cont'd...

PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	3							2	2	
CO2	2		1	2	1	2							1	1	
CO3	3	2	1	1	2	2							2	1	
CO4	3	2	1	1	2	1							2	1	
CO5	3	2	1	1	2	2							2	1	

Type	Code	Transducers & Measurement Systems	L-T-P	Credits	Marks
OE	18EI3T43		3-0-0	3	100

Objectives	The objective of this course is to study the characteristics of different types of measurement systems and industrial applications of various transducers & sensors for design & construction of precise measuring instruments.
Pre-Requisites	Basic knowledge of physics, mathematics, electrical and electronics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Definition of measurement, application & types of instruments, functional elements of generalized measurement systems, active/passive transducers, analog/digital mode of operation, null and deflection methods; **Static Characteristics**: Systematic characteristics, statistical characteristics, calibration; **Dynamic Characteristics**: Transfer functions of typical sensing elements, step and frequency response of first and second order elements, dynamic errors in measurement systems, dynamic compensation, loading effect, signal & noise.	**10 Hours**
Module-2	**Resistive Transducers**: Resistive potentiometers, strain gauges; **Inductive Transducers**: Variable reluctance displacement sensor, LVDT, RVDT, Hall effect sensors; **Capacitive Transducers**: Variable separation, area & dielectric displacement transducer, pressure, humidity and level measurement; **Translational and Rotational Velocity Measurement**: Moving coil moving magnet pickups, Eddy current magnetic & photoelectric pulse counting; **Seismic Measurement**: Seismic displacement, velocity and acceleration pickups.	**10 Hours**
Module-3	**Temperature Measurement**: Thermal expansion methods - Bimetallic, Liquid in glass, Thermocouples (Laws, Characteristics, Installation), RTDs (3-wire & 4-wire type), Thermistors, IC temperature sensors, Radiation detectors, Radiation pyrometer (Narrow Band & Broad Band), Optical pyrometer.	**9 Hours**
Module-4	**Force Measurement**: Bourdon tube, bellows, diaphragm, load cell; Torque Measurement: Torsion bar; Pressure Measurement: Units of pressure, dead weight gauges, Manometers, Mc-Leod gauge, Thermal conductivity and Ionization gauges; **Flow Measurement**: Variable Head (Orifice, Venturi, Pitot static), Variable area (Rotameters), Turbine meters, Electromagnetic flow meters, Ultrasonic flow meters, Doppler velocity meters, Hot wire anemometer and mass flow meter.	**7 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	**Signal Conditioning System**: DC Bridge - Wheatstone Bridge, Calibration of the bridge, AC bridges, Linearization by Bridge circuit, Cold junction compensation of Thermocouple, Modulation and Demodulation Techniques, Signal Conditioning System, Signal Transmission.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. A. K. Ghosh, ***Introduction to Instrumentation and Control***, 4th Edition, PHI Learning, 2012.
T2. J. P. Bentley, ***Principles of Measurement Systems***, 4th Edition, PHI Learning, 2005.

Reference Books:

R1. D. Patranabis, ***Sensors and Transducers***, 2nd Edition, PHI Learning, 2013.
R2. D. V. S. Murthy, ***Transducers and Instrumentation***, 2nd Edition, PHI Learning, 2008.
R3. E. O. Doeblin, ***Measurement Systems - Applications and Design***, 6th Edition, McGraw Hill, 2007.
R4. C. Rangan, G. Sarma, and V. S. V. Mani, ***Instrumentation : Devices and Systems***, 2nd Edition, McGraw Hill, 2017.
R5. B. G. Liptak, ***Instrument Engineers' Hand Book (Process Measurement & Analysis)***, 4th Edition, CRC Press, 2006.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105088/: by Prof. S. Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/108/105/108105062/: by Prof. S. Mukhopadhyay and Prof. S. Sen, IIT Kharagpur
3. https://nptel.ac.in/courses/108/105/108105064/: by Prof. A. Barua, IIT Kharagpur
4. https://nptel.ac.in/courses/108/108/108108147/: By Prof. H. J. Pandya, IISc Bangalore

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

CO1	Describe the principles and characteristics of measuring instruments.
CO2	Explain the use of resistance, inductance and capacitance principles for transducers.
CO3	Identify and utilize various temperature sensors used in industrial applications.
CO4	Articulate the principles and uses of different force, torque, pressure sensors and flow meters.
CO5	Analyze the design of signal conditioning circuits and evaluate their performance.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

Cont'd...

PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	1	1								2	1	1
CO2	2	3	2	2	1								3		
CO3	2	1	2	1	1								1	1	
CO4	2	3	2	3	3								1		
CO5	2	2	2	1	3								1		

Type	Code	Energy Conversion Devices	L-T-P	Credits	Marks
OE	18EE3T32		3-0-0	3	100

Objectives	The objective of the course is to study various types of electrical machines, their performance, control mechanisms, and industrial applications.
Pre-Requisites	Knowledge of basic electrical engineering, basic mathematics like calculus, and differential equations is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Transformers**: Constructional features, EMF equation, Ideal and non-ideal transformers, Turns ratio, Equivalent circuit, Losses and efficiency, Parameter estimation through Open Circuit and Short Circuit test; Three Phase Transformers: Construction and types of connections (star-delta, delta-star, star-star, delta-delta).	**10 Hours**
Module-2	**Principles of DC Machines**: Construction, Modes of excitation (self, separately), EMF induced expression; DC Generators: No load characteristics for separately excited generator and shunt generator, Voltage build up process, Critical resistance and critical speed, Losses and efficiency.	**8 Hours**
Module-3	**DC Motors**: Principle of operation, Study of different characteristics, Speed armature current, Torque armature current, Speed torque for separately excited, shunt and DC series motor, Speed control and starting of DC shunt and series motors.	**6 Hours**
Module-4	**Three Phase Synchronous Machines**: Constructional features, Principle of operation as Alternator and Synchronous motor, Synchronous impedance and voltage regulation by synchronous impedance method, Synchronization of alternators; Torque expression and Phasor diagram for synchronous motor; Electrical power and mechanical power; Starting of synchronous motor.	**8 Hours**
Module-5	**Three Phase Induction Motors**: Constructional features of Squirrel Cage Rotor type and Slip Ring/Wound Rotor type of induction motors, Principle of operation, Concept of slip, Slip torque characteristics, Starting of Squirrel Cage Rotor type and Slip Ring/Wound Rotor type of induction motors, Speed control of induction motors; **Single Phase Motors**: Double field revolving theory. Split phase (capacitor start & run) and Shaded pole starting of single phase induction motors; Speed current, Torque current and speed torque, Characteristic for universal motors.	**10 Hours**
	Total	**42 Hours**

Text Books:

T1. D. P. Kothari and I. J. Nagrath, ***Electric Machines***, 4th Edition, Tata McGraw Hill, 2010.
T2. J. B. Gupta, ***Theory & Performance of Electrical Machine***, 14th New Edition, S. K. Kataria & Sons Publication, 2015.
T3. P. S. Bimbhra, ***Electrical Machinery***, 7th Edition, Khanna Publishers, 2009.

Reference Books:

R1. A. Husain and H. Ashfaq, ***Electrical Machines***, 3rd Edition, Dhanpat Rai & Co., 2016.
R2. S. Ghosh, ***Electrical Machines***, 2nd Edition, Pearson Education, 2012.
R3. B. L. Theraja and A. K. Theraja, ***A Textbook of Electrical Technology: Volume-II AC and DC Machines***, 1st Edition, S. Chand Publications, 2006.

Online Resources:

1. https://nptel.ac.in/courses/108105017/: by Dr. D. Kastha, IIT Kharagpur
2. https://nptel.ac.in/courses/108106072/: by Prof. K. Vasudevan, Prof. G. S. Rao, Prof. P. S. Rao, IIT Madras
3. https://nptel.ac.in/courses/108/102/108102146/: by Prof. G.Bhuvaneshwari, IIT Delhi
4. https://nptel.ac.in/courses/108/105/108105155/: by Prof. T. K. Bhattacharya, IIT Kharagpur

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

CO1	Perceive the equivalent circuit of single phase transformer, determine the circuit parameters, and efficiency using various tests.
CO2	Understand the constructional features and analyze the load/no-load characteristics of DC generator.
CO3	Explain the operating characteristics and speed control techniques of DC Motors.
CO4	Generalize the constructional features of synchronous machines and analyze the process of synchronization in industries.
CO5	Describe the operating principles, starting & speed control of 3-phase induction motors and different types of single phase motors.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

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PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	3		1						3	1	
CO2	2	2	2	1									2		
CO3	1	2		2	1		1						2	1	1
CO4	2	2	1	1	1								3		
CO5	3	1	1	2	1								3	1	1

Type	Code	Stochastic Processes	L-T-P	Credits	Marks
OE	18BS3T12		3-0-0	3	100

Objectives	The objectives of this course is to gain mathematical maturity by equipping the students to handle computing probability in different conditions and studying the concepts of Markov chain & Queuing theory.
Pre-Requisites	Knowledge of Sets, Probability, and Linear Algebra is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Review of basics of Probability - Probability of an event, Conditional probability, Independent event and Bayes' formula, Random variables, Discrete and Continuous, Distribution functions, Joint distribution & independent random variables, Expectation, Variance and covariance, Variance of a sum, Conditional distribution & conditional expectation (discrete case), Conditional distribution & conditional expectation (continuous case), Computing expectation & variance by conditioning, Computing probabilities by conditioning.	**8 Hours**
Module-2	Stochastic Processes, Markov Chain - Introduction and definition, Chapman-Kolmogorov equations, Classification of states, Limiting probabilities, Some application problems, Mean time spent in transient state, Branching processes, Time reversible Markov chains.	**11 Hours**
Module-3	Markov decision process, Hidden Markov chain, Exponential distribution and its properties, Counting process & definition of Poisson process, Inter arrival & waiting time distribution, Further properties of Poisson process, Non-homogeneous Poisson process.	**8 Hours**
Module-4	Continuous-time Markov chain, Birth & death process, The transition probability function, Limiting probabilities, Time reversibility, Computing the transition probabilities.	**7 Hours**
Module-5	Terms & notations in Queuing Theory, Steady state probabilities, A single server exponential queuing system (M/M/1), M/M/1 system with finite capacity, An application problem, The system M/G/1, Multiserver queues.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. M. Ross, ***Introduction to Probability Models***, 10th Edition, Academic Press, 2009.

Reference Books:

R1. J. Medhi, ***Stochastic Processes***, 4th Edition, New Age International, 2019.

Online Resources:

1. https://nptel.ac.in/courses/110/101/110101141/: by Prof. M. Hanawal, IIT Bombay
2. https://nptel.ac.in/courses/111/102/111102111/: by Dr. S. Dharmaraja, IIT Delhi
3. https://nptel.ac.in/courses/115/106/115106089/: by Prof. V. Balakrishnan, IIT Madras
4. https://nptel.ac.in/courses/111/102/111102098/: by Dr. S. Dharmaraja, IIT Delhi

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

CO1	Apply probability models to real life engineering problems.
CO2	Explain Markov chain and classification of states.
CO3	Solve problems using the concepts of hidden Markov chain and Poisson process.
CO4	Apply Markov chain in problems of different field of engineering.
CO5	Apply Queuing theory in engineering and daily life situations.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1								2	1	1
CO2	3	3	2	2	2								2	1	1
CO3	3	2	2	2	2								2	1	1
CO4	3	3	2	2	3								2	1	1
CO5	3	3	3	3	3								2	1	1

Type	Code	Organizational Behaviour	L-T-P	Credits	Marks
OE	18BS3T07		3-0-0	3	100

Objectives	The objective of this course is to understand the human interactions in an organization and develop the skills for leadership, conflict resolution and take rational decisions to attain business goals.
Pre-Requisites	General knowledge of any organization and its operations is sufficient.
Teaching Scheme	Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with real-life examples.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction: Concept and Importance of Organizational Behaviour; Learning-Nature of Learning, Components of learning, Learning Cycle, Theories of Learning; Personality - Concept, Determinants of Personality, Personality Traits, Personality and OB.	**9 Hours**
Module-2	Perception and Motivation: Perception - The Concept of Perception, The perceptual process, Importance of Perception in OB; Motivation: Nature and Importance, Herzberg's Two Factor Theory, Maslow's Need Hierarchy Theory, Alderfer's ERG Theory.	**8 Hours**
Module-3	Organizational Behaviour Process: Communication-Concept, Importance, Types, Gateways and Barriers to Communication; Communication as a tool for improving Interpersonal Effectiveness. Groups in Organizations: Nature and Types of Groups, Group Cohesiveness and Group Decision-making with Managerial Implications, Effective Team Building. Leadership: Leadership and Management, Theories of Leadership, Conflict-Nature of Conflict and Conflict Resolution.	**9 Hours**
Module-4	Organizational Culture and Human Resource Management: Organizational Culture: Concept of Organizational Culture and Organizational Effectiveness; Human Resource Management: Selection, Orientation, Training and Development, Performance Appraisal.	**8 Hours**
Module-5	Organizational Change: Importance of Change, Planned Change and OB techniques; International Organizational Behavior: Cultural Differences and Similarities, Individual and Interpersonal Behavior in Global Perspective, Trends in International Business.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. K. Davis, ***Organisational Behaviour***, 9th Edition, McGraw-Hill, 1992.
T2. K. Aswathappa, ***Organisational Behaviour***, 12th Rev. Edition, Himalaya Publishing House, 2016.

Reference Books:

R1. S. P. Robbins, ***Organisational Behaviour***, 8th Edition, Prentice Hall of India, 2018.

R2. K. B. L. Srivastava and A. K. Samantaray, ***Organizational Behaviour***, 1st Edition, India Tech, 2009.
R3. K. Singh, ***Organizational Behaviour***, 3rd Edition, Pearson, 2015.

Online Resources:

1. https://nptel.ac.in/courses/110/105/110105033/: by Dr. S. Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/110/105/110105120/: by Prof. K. B. L. Srivastava, IIT Kharagpur
3. https://www.studocu.com/en/search/organizational-behaviour: by different universities

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

CO1	Describe the developments in the field of OB and the micro & macro approaches inside organizations.
CO2	Analyze and compare different models used to explain individual behaviour related to motivation, learning, perception and personality.
CO3	Identify the processes used in developing communication, interpersonal relations and resolving conflicts.
CO4	Explain the role of group dynamics, demonstrate skills required for working in groups, team building and various leadership styles.
CO5	Explain the need of organizational culture and identify the process and barriers for implementing organizational change.

Program Outcomes Relevant to the Course:

PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						1	1	1	1			1		1	1
CO2						1	1	2	1	1		1		2	1
CO3						1		2	3	3		1		2	2
CO4						1	2	1	3	1		1		3	2
CO5						2	1	1	1	1		1		2	1

Type	Code	Communication Systems Engineering	L-T-P	Credits	Marks
OE	18EC3T28		3-0-0	3	100

Objectives	The objective of this course is to study electronic communication systems, modulation techniques, digital transmission of analog signals, random variables, and sources & filtering of noise.
Pre-Requisites	Knowledge of signals & systems and probability theory is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Signals and Spectra**: An Overview of Electronic Communication Systems, Types of Signal, Fourier Series, Fourier Transform, Properties of Fourier Transform, Orthogonal Signal.	**8 Hours**
Module-2	**Amplitude Modulation Systems**: Need for frequency translation, Double Side Band with Carrier (DSB-C), Double Side Band with Suppressed Carrier (DSB-SC), Modulators - Square-law, Switching, Balanced; Detectors: Square-law, Envelope, Synchronous; Single Side Band with Suppressed Carrier (SSB-SC), Frequency & Phase discrimination methods, Coherent detection, Modulation & demodulation of Vestigial Side Band modulation (VSB), Frequency Division Multiplexing, Radio Transmitter & Receiver (super heterodyne receiver).	**9 Hours**
Module-3	**Angle Modulation**: Angle Modulation, Narrow band FM, Wide band FM; FM Modulators: Direct method (Varactor diode method), Indirect method (Armstrong method), Simple slope detector, Balanced slope detector, Phase Locked Loop (PLL). **Analog Pulse Modulation**: Analog to Digital - The need, Sampling Theorem, Natural and Flat-top sampling, Quantization of signals, Quantization error, Pulse Amplitude Modulation, Pulse Width Modulation and Pulse Position Modulation.	**9 Hours**
Module-4	**Digital Pulse Modulation**: The PCM system, Bandwidth of PCM system, Delta Modulation (DM), Limitation of DM, Adaptive Delta Modulation, Differential PCM (DPCM), Comparison between PCM, DM, and DPCM. **Digital Transmission of Analog Signal**: Digital representation of analog signal, Line codes, Companding, Concept of Time Division Multiplexing, Multiplexing of PCM signals.	**8 Hours**
Module-5	**Random Variables and Processes**: Probability, Random variables, Useful probability density functions, Useful properties and certain application issues. **Mathematical Representation of Noise**: Sources of noise, Frequency-domain representation of noise, Superposition of noises, Linear filtering of noise, Noise bandwidth.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. H. Taub, D. L. Schilling, and G. Saha, ***Principles of Communication System***, 4th Edition, Tata McGraw Hill, 2013.
T2. R. P. Singh and S. D. Sapre, ***Communication Systems : Analog and Digital***, 3rd Edition, McGraw Hill Education, 2012.

Reference Books:

R1. J. G. Proakis and M. Salehi, ***Communication System Engineering***, 2nd Edition, PHI, 2002.
R2. S. Haykin and M. Moher, ***Communication Systems***, 5th Edition, John Wiley & Sons, 2009.
R3. B. P. Lathi, Z. Ding, and H. M. Gupta, ***Modern Digital and Analog Communication Systems***, 4th Edition, Oxford University Press, 2017.

Online Resources:

1. https://nptel.ac.in/courses/117105143/: by Prof. G. Das, IIT Kharagpur
2. https://nptel.ac.in/courses/108/104/108104091/: by Prof. A. Jagannathan, IIT Kanpur
3. https://nptel.ac.in/courses/117/105/117105144/: by Prof. S. S. Das, IIT Kharagpur

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

CO1	Explain different types of signals and their characteristics using Fourier analysis tools.
CO2	Describe the fundamentals of amplitude modulation and demodulation techniques.
CO3	Articulate performance of angle modulation techniques and various analog pulse modulation schemes.
CO4	Explain different types of digital pulse modulation schemes and digital transmission of analog signals.
CO5	Visualize the behavior of random variables, noise signal in frequency domain, and linear filtering of noise.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2							1	2		1
CO2	3	3	3	2	2							1	3		1
CO3	3	3	2	2	2							1	3		1
CO4	3	3	3	2	2							1	3		1
CO5	3	3	2	2	2							1	2		1

Type	Code	Biomedical Instrumentation & Signal Processing	L-T-P	Credits	Marks
OE	18EI3T05		3-0-0	3	100

Objectives	The objective of this course is to study various biomedical instruments, sensors and signal processing techniques, and their applications in diagnosis, therapeutic and surgical procedures.
Pre-Requisites	Knowledge of basic electronics, sensors, and transducers is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on real-world applications.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction to Bioengineering**: Sources and examples of biomedical signals, Basic medical Instrumentation system, use of microprocessors, general design constraints; Transducers: Classification, Transducers for Biomedical Applications; Sources of Bio-electric Potentials: Resting and Action Potentials; Anatomy of heart, Different types of Biomedical Signals: ECG, PCG, EEG, EMG.	**9 Hours**
Module-2	**Biomedical Electrodes and Recorders**: Electrode theory, Recording electrodes, Bio-potential Electrodes for ECG, EEG and EMG, Microelectrodes, ECG recorder, Sources of Artifacts in ECG and their removal methods, EEG & EMG recorder.	**8 Hours**
Module-3	**Patient Care Monitoring**: System concepts, Measurement of heart rate, Measurement of pulse rate, Blood pressure and blood flow measurement, Pacemakers and Defibrillators, Electric shock hazards, Leakage currents.	**8 Hours**
Module-4	**X-Ray and Radioisotope Instrumentation**: Generation of Ionizing Radiation, Nature and production of X-Rays, Computed Tomography, Magnetic Resonance Imaging System, Ultrasonic Imaging Systems.	**8 Hours**
Module-5	**Adaptive Filters**: Principle, the steepest descent algorithm, adaptive noise canceller, cancellation of interference in electrocardiography, applications; Canceling Donor heart Adaptive filters, HF noise in ECG, motion artifact in ECG, maternal interference in Fetal ECG, cancellation of maternal ECG, cancellation of ECG signal from electrical activity of chest muscles, cancellation of HF noise in Electro-surgery.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. R. S. Khandpur, ***Handbook of Biomedical Instrumentation***, 2nd Edition, McGraw-Hill, 2002.
T2. D. C. Reddy, ***Biomedical Signal processing - Principles & Techniques***, 1st Edition, McGraw-Hill, 2005.
T3. R. M. Rangayyan, ***Biomedical Signal Analysis - A Case Study Approach***, 2nd Edition, John Willey & Sons, 2002.

Reference Books:

R1. J. L. Cromwell, F. J. Weibell, and E. A. Pfeiffer, ***Biomedical Instrumentation and Measurement***, 2nd Edition, Prentice Hall of India, 2017.
R2. J. J. Carr and J. M. Brown, ***Introduction to Biomedical Equipment Technology***, 4th Edition, Pearson Education, 2000.
R3. H. E. Thomas, ***Handbook of Biomedical Instrumentation and Measurement***, 1st Edition, Reston Publishing Company, 1974.

Online Resources:

1. https://nptel.ac.in/courses/102101068/: by Prof. S. Srivastava, IIT Bombay
2. https://nptel.ac.in/courses/108105101/: by Prof. S. Mukhopadhyay, IIT Kharagpur
3. https://ocw.mit.edu/courses/biological-engineering/20-010j-introduction-tobioengineering-be-010j-spring-2006/videos/

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

CO1	Describe the principles and design of biomedical instruments and applications of biomedical engineering.
CO2	Explain design considerations for medical equipment with respect to the human physiological system.
CO3	Describe the principle of operation of various medical recording and imaging systems.
CO4	Identify the elements of risk for different instrumentation methods and basic electrical safety.
CO5	Explain different adaptive methods for biomedical signal processing and noise cancellation.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

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PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	1			1	3			1		2		
CO2	1	1	2	3	1			2					2		
CO3	2	2	1	2		1	2	2					2	1	
CO4	2	1	2	2		1		3					1		
CO5	3	2	1	2		2		1					1	1	

Type	Code	Renewable Energy Systems	L-T-P	Credits	Marks
OE	18EE3T40		3-0-0	3	100

Objectives	The objective of this course is to study various types of renewable energy sources, the technologies for generation, storage, and proper utilization of renewable energy.
Pre-Requisites	Basic knowledge on semiconductor physics, fluid dynamics and electrical machines is required.
Teaching Scheme	Regular classroom lectures with use of ICT as needed, sessions are planned to be interactive with focus on real world examples and case-studies.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction: Conventional & non-conventional energy sources, their impact, availability, variability, Indian and world scenario; Solar, Wind, Biomass, Wave, Tidal, Geothermal energy systems; Solar Energy: Solar processes, Composition of solar radiation; Extra-terrestrial & terrestrial radiation, Angles - Azimuth, Zenith, Hour; Irradiance, Solar constant; Solar Thermal Systems & Applications: Solar collectors, Types & performance characteristics, Water heating systems (active & passive), Space heating & cooling systems, Desalination systems, Solar cooker, Solar thermal power plant.	**8 Hours**
Module-2	Solar Photovoltaic System: Operating principle, Photovoltaic cell concepts, Cell, Module, Array, Losses in solar cell, Effects of partial & complete shadowing, Series and parallel connections, Cell mismatching, PV voltage-current characteristics, Equivalent circuit, Maximum power point tracking; Applications: battery charging, Pumping, Lighting, Peltier cooling.	**10 Hours**
Module-3	Biomass Power: Principles of biomass conversion, Combustion and fermentation, Anaerobic digestion, Types of biogas digester, Wood gasifier, Pyrolysis, Applications, Biogas, Wood stoves, Bio diesel, Combustion engine, Urban waste to energy conversion, Biomass based power generation.	**9 Hours**
Module-4	Wind Energy: Wind energy, Variability, Conversion principle; Wind power density, Efficiency limit, Types of converters, Aerodynamics of rotors, Power∼Speed and Torque∼Speed characteristics, Wind turbine control systems; Conversion to Electrical Power: Induction and synchronous generators, Grid connected & self excited induction generator operation, Constant voltage & constant frequency generation with power electronic control, Single & double output systems, Reactive power compensation, Characteristics of wind power plant, Concepts of DFIG.	**10 Hours**

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Module-#	Topics	Hours
Module-5	Energy Storage Systems: Batteries, Ultra capacitors, SMES; Fuel Cell: Fuel Cell Basics, History of fuel cell technology, Open circuit voltage, Nernst equation analysis, Causes for voltage loss, Types of fuel cell and their efficiency, Applications; Introduction to Hybrid Energy Systems: PV-Wind, PV-Fuel Cell, PV-Diesel.	**5 Hours**
	Total	**42 Hours**

Text Books:

T1. G. Boyel, ***Renewable Energy - Power for a Sustainable Future***, 3rd Edition, Oxford University Press, 2012.
T2. B. H. Khan, ***Non-Conventional Energy Resources***, 3rd Edition, McGraw Hill Education, 2017.
T3. S. N. Bhadr, D. Kastha, and S. Banerjee, ***Wind Electrical Systems***, 7th Edition, Oxford University Press, 2005.

Reference Books:

R1. S. A. Abbasi and N. Abbasi, ***Renewable Energy Sources and Their Environmental Impact***, 1st Edition, PHI Learning, 2004.
R2. S. H. Saeed and D. K. Sharma, ***Non-Conventional Energy Resources***, 4th Edition, S. K. Kataria & Sons, 2019.
R3. S. Peake, ***Renewable Energy : Power for a Sustainable Future***, 4th Edition, Oxford University Press, 2018.

Online Resources:

1. https://nptel.ac.in/courses/103/107/103107157/: by Prof. B. Mondal, IIT Roorkee
2. https://nptel.ac.in/courses/108/105/108105058/: by Prof. S. Banerjee, IIT Kharagpur
3. https://nptel.ac.in/courses/121/106/121106014/: by Dr. P. Haridoss, IIT Madras

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

CO1	Generalize solar thermal systems and identify various alternate energy sources & their characteristics.
CO2	Analyse and design a solar photovoltaic system for specified applications.
CO3	Evaluate the effectivenss of biomass energy conversion in waste management.
CO4	Design wind energy systems and analyze their operational characteristics.
CO5	Investigate the operation of fuel cell and configuration of different hybrid energy systems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

Cont'd...

PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	1	1	2	2					1	3	1	1
CO2	3	1	2	2	2	1	2					1	2	3	2
CO3	1	1	2	1	1	2	3					1	2	1	1
CO4	3	1	2	2	2	1	3					1	3	2	2
CO5	1	1	2	2	1	1	2					1	2	1	1

Type	Code	Graph Theory	L-T-P	Credits	Marks
OE	18BS3T34		3-0-0	0	100

Objectives	Graph Theory is essential for modern engineering to design circuits, analyze data structures and algorithms, to solve problems on counting and combinatory and many more different studies. The present course aims at providing a basic foundation on graph theory.
Pre-Requisites	Knowledge of Sets, Matrix algebra, permutation and combinations is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Graphs, definition and models, Matrices and isomorphism, Decomposition and special graphs, Connections in graphs, Bipartite graphs, Eulerian circuits, Counting and bijections, Extremal problems, Graphic sequences.	**8 Hours**
Module-2	Directed graphs and vertex degree, Eulerian digraphs Properties of trees, Distance in trees and graphs, Enumeration of trees, Spanning trees in graph, Minimum spanning tree, Shortest paths.	**9 Hours**
Module-3	Maximum matchings, Hall's matching conditions, Mini-Max Theorem, Independent sets, Covers and dominating sets, Connectivity and edge connectivity, Blocks, 2-connected graphs, Connectivity of diagraphs-connected and k-edge-connected graphs, Maximum network flow.	**10 Hours**
Module-4	Vertex Colorings and upper bounds, Brooks' Theorem, Counting Proper colorings, Chromatic polynomials, Drawings in the plane, Dual graphs, Euler's formula, Preparation for Kuratowski's theorem, Convex Embedding, Coloring of planar graph.	**9 Hours**
Module-5	Edge-colorings, Necessary conditions for Hamilton cycles, Sufficient conditions for Hamilton cycles, Cycles in Directed graph.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. D. B. West, ***Introduction to Graph Theory***, 2nd Edition, Pearson Education, 2019.

Reference Books:

R1. J. A. Bondy and U. S. R. Murty, ***Introduction to Graph Theory***, 1st Edition, Springer, 2008.
R2. F. Harary, ***Graph Theory***, 1st Edition, Narosa Publishers, 2013.

Online Resources:

1. https://nptel.ac.in/courses/111/106/111106102/: by Dr. S. Maity, IISER Pune

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

CO1	Know basic terminologies and notations in graph theory.
CO2	Understand trees and learn and apply methods to find optimum paths and spanning trees.
CO3	Understand and apply matching theorems to solve network flow problems.
CO4	Classify planarity and coloring in graph.
CO5	Apply Hamiltonian cycle to travelling salesman problem.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1								2	1	1
CO2	3	3	3	2	2								2	1	1
CO3	3	3	2	2	3								2	1	1
CO4	3	3	2	2	1								2	1	1
CO5	3	3	3	2	1								2	1	1

Type	Code	Financial Management	L-T-P	Credits	Marks
OE	18BS3T44		3-0-0	3	100

Objectives	The objective of this course is to offer the students relevant, systematic, efficient and actual knowledge of financial management that can be applied in practice with making financial decisions and resolving financial problems.
Pre-Requisites	Basic knowledge on concepts of finance is required.
Teaching Scheme	Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with real-life examples.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Business Finance - concept, types & scope; Financial Management - Objectives, functions & scope; Interface of financial management with other functional areas; Role of Finance Manager; Financial forecasting and Financial planning; Risk and Return - concept, Relationship between risk and return, Risk Diversification.	**10 Hours**
Module-2	**Investment Decisions**: Capital Budgeting Process; Techniques of Capital Budgeting - Discounted and Non- Discounted Cash Flow Methods; Capital Rationing; Risk Evaluation and Sensitivity Analysis. Estimation of cash flow for new & replacement projects, Risks in capital budgeting.	**8 Hours**
Module-3	**Financing Decisions**: Sources of long-term financing, Estimation of components of cost of capital, Methods for calculating Cost of Equity, Cost of Retained Earnings, Cost of Debt and Cost of Preference Capital, Weighted Average Cost of Capital (WACC).	**8 Hours**
Module-4	**Dividend Decisions**: Dividend and its forms, Objectives of dividend policy, Relevance and irrelevance; Factors affecting the dividend policy, Dividend payout procedures, Types of dividends, Measures of dividend policy, Theories of dividend decisions - Walter's Approach, Gordon's Approach, MM Approach.	**6 Hours**
Module-5	**Working Capital Decisions**: Concepts of working capital, Sources of short-term finance, Working capital estimation, Cash budgeting, Long-term cash forecasting, Optimal cash balance, Investment of surplus fund; Inventory Management - Need for inventory, Order quantity - EOQ model, Monitoring and control of inventory, Receivables Management - Meaning and objective, Cost and benefit of receivable management, Factors influencing the size of investment in receivables, Credit evaluation of individual accounts, Monitoring accounts receivable.	**10 Hours**
	Total	**42 Hours**

Text Books:

T1. M. Y. Khan and P. K. Jain, ***Financial Management***, 7th Edition, McGraw-Hill Education, 2017.

Reference Books:

R1. R. A. Brealey, S. C. Myers, and F. Allen, ***Principles of Corporate Finance***, 12th Edition, McGraw-Hill Education, 2018.
R2. C. Prasanna, ***Financial Management : Theory & Practice***, 10th Edition, Tata McGraw-Hill, 2019.
R3. J. C. Vanhorne and J. M. Wachowicz Jr., ***Fundamentals of Financial Management***, 12th Edition, Pearson Education, 2004.
R4. L. J. Gitman, ***Principles of Managerial Finance***, 13th Edition, Pearson Education, 2017.
R5. I. M. Pandey, ***Financial Management***, 11th Edition, Vikas Publishing House, 2016.

Online Resources:

1. https://nptel.ac.in/courses/110/107/110107144/: by Prof. A. K. Sharma, IIT Roorkee
2. https://bbamantra.com/financial-management-introduction-part-1/
3. https://www.accountingtools.com/articles/what-is-capital-budgeting.html
4. https://cleartax.in/s/capital-budgeting
5. https://efinancemanagement.com/dividend-decisions
6. https://efinancemanagement.com/working-capital-financing/working-capital-management

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

CO1	Understand the concept of financial management and its application.
CO2	Evaluate engineering projects through different accounting tools.
CO3	Calculate the cost of capital and other financial indicators of different projects.
CO4	Assess the factors affecting dividend decisions and its policy.
CO5	Apply the scientific techniques for managing working capital.

Program Outcomes Relevant to the Course:

PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1								1	1	1	3	1	2		1
CO2								1		1	3	1		1	3
CO3									1	1	3	1		1	2
CO4								1	2	1	3	1		1	3
CO5								1	1	1	3	1		2	2

Type	Code	Introduction to Digital Signal Processing	L-T-P	Credits	Marks
OE	18EC3T36		3-0-0	3	100

Objectives	The objective of this course is to study various signals and systems in time & spectrum domains, investigate the stability & causality of systems, understand Z-transform, discrete Fourier transform and their properties, and to understand design of IIR & FIR filters.
Pre-Requisites	Knowledge of complex numbers and elementary calculus is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Signals & Systems: Introduction to Signal, Classification, Convolution of two signals (graphical & analytical); Introduction to System, Classification, Continuous-time & Discrete-time LSI system, System representation through differential & difference equations, Response of LSI system, Convolution Integral, Convolution Sum, Correlation of Discrete-time signals & its properties.	**10 Hours**
Module-2	Discrete Time Signals: Z-Transform, Region of convergence, Properties of Z-transform, Inverse Z-transform (power series & partial fraction methods); Analysis of LSI systems: causality and stability using Z-transform, pole-zero concept and pole-zero cancellation, transient and steady state response; Unilateral Z-transform and its properties, solution of difference equations.	**8 Hours**
Module-3	Discrete Fourier Transform: Basics of Discrete Time Fourier Transform (DTFT), frequency domain sampling and reconstruction of discrete time signals; Discrete Fourier Transform (DFT) and its properties; Linear filtering (overlap add method and overlap save method); Efficient computation of DFT: Fast Fourier Transform (FFT) Algorithm (Radix-2 DIT and Radix-2 DIF).	**8 Hours**
Module-4	Structure for Realization of Discrete Time Systems: Structure for IIR systems - Direct Form I, Direct Form II, Cascade and Parallel Form, Signal Flow Graph and Transposed Structure; Structure for FIR systems: Direct form, cascade form and frequency sampling structure.	**8 Hours**
Module-5	Design of Digital Filters: Causality and its implication; Design of FIR filters: symmetric and anti-symmetric, design of Linear Phase FIR filters using Windowing technique and frequency sampling technique; Design of IIR Filters from analog filters using Impulse invariance and bilinear transformation techniques.	**8 Hours**
	Total	**42 Hours**

P.T.O

Text Books:

T1. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, ***Signals and Systems***, 2nd Edition, Prentice Hall India, 1992.
T2. B. P. Lathi, ***Principles of Signal Processing and Linear Systems***, 2nd Edition, Oxford University Press, 2009.
T3. J. G. Proakis and D. G. Manolakis, ***Digital Signal Processing : Principles, Algorithms and Applications***, 4th Edition, Prentice Hall India, 2007.
T4. S. K. Mitra, ***Digital Signal Processing : A Computer Based Approach***, 4th Edition, McGraw Hill, 2013.

Reference Books:

R1. A. Ambardar, ***Analog and Digital Signal Processing***, 2nd Edition, Brooks/Cole Publishing Company (an International Thomson Publishing Company), 1999.
R2. M. J. Roberts, ***Signals and Systems - Analysis using Transform Methods and MATLAB***, 2nd Edition, McGraw hill, 2003.
R3. A. N. Kani, ***Signals and Systems***, 2nd Edition, McGraw Hill Education, 2010.
R4. A. N. Kani, ***Digital Signal Processing***, 2nd Edition, McGraw Hill Education, 2012.
R5. P. R. Babu, ***Digital Signal Processing***, 4th Edition, SciTech Publication, 2011.

Online Resources:

1. https://nptel.ac.in/courses/117104074/: by Prof. K. S. Venkatesh, IIT Kanpur
2. https://nptel.ac.in/courses/108105065/: by Prof. T. K. Basu, IIT Kharagpur
3. https://nptel.ac.in/courses/108104100/: by Prof. A. K. Jagannatham, IIT Kanpur
4. https://nptel.ac.in/courses/117101055/: by Prof. V. M. Gadre, IIT Bombay

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

CO1	Explain different types of signals and analyze various types of LSI systems responses.
CO2	Investigate the systems stability and causality using Z-Transform.
CO3	Analyze discrete signals and systems using DFT technique.
CO4	Realize different structures of FIR and IIR discrete time systems.
CO5	Design IIR and FIR filters using various techniques.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Cont'd...

PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	1	2	2								2		
CO2	2	1	1	2	2	1							2	1	
CO3	2	1	1		1	1							1	1	
CO4	1	2	3	2	2	2							2	1	
CO5	2	2	2	1	1	2							2	1	

Type	Code	Introduction to VLSI Design	L-T-P	Credits	Marks
OE	18EI3T37		3-0-0	3	100

Objectives	The objective of this course is to study design of circuits and systems using integrated micro fabrication technologies and providing an overall state of art knowledge in the area of VLSI Design.
Pre-Requisites	Fundamental knowledge of MOSFET and digital electronics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Historical Perspective, VLSI Design Methodologies, VLSI Design Flow, Design Hierarchy, Concept of Regularity, Modularity and Locality, VLSI Design Styles. **Fabrication of MOSFETs**: Introduction, Fabrication Process Flow – Basic Concepts, The CMOS n-Well Process, Layout Design Rules, Stick Diagrams and Layout of complex CMOS Logic Gates (Euler Method).	**8 Hours**
Module-2	**MOS Transistor**: The Metal Oxide Semiconductor (MOS) Structure, The MOS System under External Bias, Structure and Operation of MOS Transistor (MOSFET), MOSFET Current-Voltage Characteristics, MOSFET Scaling and Small-Geometry Effects, MOSFET Capacitance.	**8 Hours**
Module-3	**MOS Inverter Circuits**: Introduction, Voltage Transfer Characteristics, Noise Margin Definitions, CMOS Inverter, Sizing of Inverters. **Static MOS Gate Circuits**: Introduction, CMOS Gate circuits, Complex CMOS Gates, MUX circuits, Calculation of inverter equivalent for NAND, NOR and other Complex Logic Circuits.	**9 Hours**
Module-4	**High Speed CMOS Logic Design**: Introduction, Switching Time Analysis, Detailed Load Capacitance Calculation, Improving Delay Calculation with Input Slope, Calculation of Interconnect Parasitics, Calculation of Interconnect Delay (Elmore Delay), Gate Sizing for Optimal Path Delay, Power Dissipation in CMOS Gates, Power and Delay Tradeoffs.	**9 Hours**
Module-5	**Transfer Gate Logic Design**: Introduction, Basic Concepts of Pass Transistor, CMOS Transmission Gate Logic. **Basics of Semiconductor Memory**: DRAM, SRAM Cell Design & Operation, Memory Architecture.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. -M. Kang and Y. Leblebici, ***CMOS Digital Integrated Circuits - Analysis and Design***, 3rd Edition, TMH, 2002.

T2. D. A. Hodges, H. G. Jackson, and R. Saleh, ***Analysis and Design of Digital Integrated Circuits in Deep Submicron Technology***, 3rd International Edition, McGraw Hill Education, 2004.

Reference Books:

R1. J. P. Rabaey, A. P. Chandrakasan, and B.Nikolić, ***Digital Integrated Circuits: A Design Perspective***, 2nd Edition, Pearson Education, 2016.
R2. N. H. E. Weste, D. Harris, and A. Banerjee, ***CMOS VLSI Design - A Circuits and Systems Perspective***, 4th Edition, Pearson Education, 2010.
R3. R. J. Baker, ***CMOS Circuit Design, Layout, and Simulation***, 3rd Edition, John Wiley & Sons, 2010.
R4. D. A. Pucknell and K. Eshraghian, ***Basic VLSI Design***, 3rd Edition, PHI Learning, 1995.
R5. J. P. Uyemura, ***Introduction to VLSI Circuits and Systems***, John Wiley & Sons, 2006.
R6. W. Wolf, ***Modern VLSI Design - System on Chip Design***, 3rd Edition, Pearson Education, 2004.

Online Resources:

1. https://nptel.ac.in/courses/117/106/117106092/
2. https://nptel.ac.in/courses/117/106/117106093/
3. https://nptel.ac.in/courses/117101058/
4. https://nptel.ac.in/courses/108/107/108107129/
5. https://nptel.ac.in/courses/106/105/106105161/

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

CO1	Identify suitable method to design circuits and systems using modern tools by following appropriate design flow and fabrication steps.
CO2	Explain the structure and operational analysis of MOSFET under external bias condition before and after scaling.
CO3	Design, implement and investigate Inverter, combinational and sequential logic circuits using CMOS technology.
CO4	Investigate switching characteristics of inverter to estimate its delay time and power consumption.
CO5	Design and analyze transmission gates, various memory cells, acquire the knowledge of different testing techniques and their reliability.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Cont'd...

PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	1	1	1	1				2	1	1		1
CO2	3	2		1	1								1		
CO3	2	3	3	1	1							1	2	1	2
CO4	2	1	2	2	1								1		1
CO5	2	2	2	1	1							1	2	1	2

Type	Code	Energy Studies	L-T-P	Credits	Marks
OE	18EE3T33		3-0-0	3	100

Objectives	The objective of this course is to study energy systems with emphasis on technologies & initiatives for renewable & alternative energy sources.
Pre-Requisites	General knowledge on physics, electricity, and environment is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on examples and case studies.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Sources of Energy**: Conventional & non-conventional sources of energy, Fossil fuels, Nuclear fuels, hydel, solar, wind and bio fuels in India, Energy conservation, Nuclear energy through fission and fusion processes.	**8 Hours**
Module-2	**Energy Conversion**: Energy conversion routes, Direct and indirect ways of energy conversion, Basic conversion techniques for Solar, Nuclear, Geothermal, Tide and Wind Energies.	**8 Hours**
Module-3	**Energy & Environment**: Energy efficiency & conservation, Clean energy technologies, Importance in sustainable development, Greenhouse effect, Carbon footprint, Energy consumption & sustainability, Economics of energy, Economics of production versus consumption, Linkages between economic & environmental outcomes, Influence of economic, environmental, trade, and research policies on future energy.	**8 Hours**
Module-4	**Global & Indian Energy Scenario**: Role of energy in economic development & social transformation, Overall energy demand, Availability & consumption, Depletion of energy resources & its impact on economy, Nonproliferation of nuclear energy; International energy policies of G-8, G-20, OPEC and European union countries, Kyoto protocol, Paris convention & other initiatives; Indian Energy Scenario: Commercial & non-commercial forms of energy, Utilization pattern in the past & present, Future prediction, Sector-wise energy consumption, Indian Energy Policy & regulation, Energy policy issues at global level, National level and state level, Energy Conservation Act 2001, Restructuring of Indian power sector & Electricity Act 2003, Energy pricing & its impact on global variations, National solar mission.	**10 Hours**
Module-5	**Energy Conservation**: Fundamentals of energy conservation, Energy management in power plant, Energy conservation in buildings, Heating, Ventilation, Evaluation of heat loss, Heat gain in building systems & air-conditioning system, Degree day in energy use monitoring, Energy conservation opportunities in chemical industries, Waste heat recovery, Co-generation, Energy conservation in agricultural sector, Energy conservation in illumination engineering.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. G. Boyel, ***Renewable Energy - Power for a Sustainable Future***, 3rd Edition, Oxford University Press, 2012.
T2. R. A. Ristinen and J. P. Kraushaar, ***Energy and the Environment***, 2nd Edition, John Wiley & Sons, 2006.
T3. F. Kreith and D. Y. Goswami, ***Energy Management and Conservation Handbook***, 1st Edition, CRC Press, 2017.

Reference Books:

R1. S. A. Abbasi and N. Abbasi, ***Renewable Energy Sources and Their Environmental Impact***, Pentice Hall of India, 2004.
R2. D. R. Jalilvand and K.Westph, ***The Political and Economic Challenges of Energy in the Middle East and North Africa***, 1st Edition, Routledge (Taylor & Francis Group), 2017.
R3. J. Goldemberg, ***World Energy Assessment: Energy and the Challenge of Sustainability***, United Nations, 2001.
R4. B. H. Khan, ***Non-Conventional Energy Resources***, 3rd Edition, Tata McGraw-Hill, 2017.

Online Resources:

1. https://en.wikipedia.org/wiki/Kyoto_Protocol
2. https://en.wikipedia.org/wiki/Paris_Agreement

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

CO1	Identify various alternate energy sources and their characteristics.
CO2	Analyze different energy conversion techniques for renewable energy systems.
CO3	Evaluate the effect of energy consumption on environment, economy and development.
CO4	Visualize global & national energy scenario and international energy policies.
CO5	Investigate different energy conservation techniques and energy management systems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1				1	2					1	1	2	1
CO2	1	1				1	2					1	1	2	1
CO3						2	3	1				1		2	1
CO4						2	3	1				1		2	1
CO5	1	2				3	3	2				1	1	2	2

Type	Code	Simulation & Modelling	L-T-P	Credits	Marks
OE	18BS3T18		3-0-0	3	100

Objectives	The objective of this course is to learn the basic concepts and steps of statistical simulation along with some modeling problems for engineering, scientific, business, and social science processes in the real life.
Pre-Requisites	Basic knowledge of probability and statistics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Basic concepts of Queue, M/M/1 and M/M/s queues, Queues involving non exponential distributions, Inventory models, Deterministic Continuous review model, Deterministic Periodic review model.	**8 Hours**
Module-2	Random number generation and its application to integration, Estimation of π and other problems, Generating discrete random variable: Inverse Transform Method, Generating geometric random variable and Bernoulli Random variable, Generating Poisson and Binomial random variable, The Acceptance Rejection method, The composition Approach, Programming for Generation of discrete random variable.	**9 Hours**
Module-3	Generation of Continuous random variable: The inverse transform method, The rejection Method, Generating Normal random variable by different methods, Generating Poisson Process, Simulating a single server queuing system, A queuing system with two servers in series, A queuing system with two servers in parallel, An inventory Model, An Insurance Risk model.	**10 Hours**
Module-4	Simulation of A Repair model, Programming for simulation model, Reduction of Variance using Antithetic variables, Estimation of system reliability using antithetic variables, Application Problems, Reduction of variance using Control Variates, Application Problems, Variance by conditioning, Application Problems.	**8 Hours**
Module-5	Stratified Sampling, Reduction of variance using stratified sampling, Goodness of Fit for Discrete Data, Kolmogorov-Smirnov Test for Continuous Data, Goodness of Fit test when some parameters are unspecified, Two sample problem.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. F. S. Hillier and G. J. Lieberman, ***Introduction to Operations Research***, 8th Edition, McGraw-Hill, 2005.
T2. S. M. Ross, ***Simulation***, 5th Edition, Academic Press, 2012.

Reference Books:

R1. A. M. Law and W. D. Kelton, ***Simulation Modeling and Analysis***, 4th Edition, McGraw-Hill Higher Education, 2005, Online: https://fac.ksu.edu.sa/sites/default/files/index.pdf.
R2. H. A. Taha, ***Operations Research***, 8th Edition, Pearson Education, 2006.

Online Resources:

1. https://nptel.ac.in/courses/110106062/: by Prof. G. Srinivasan, IIT Madras
2. https://nptel.ac.in/courses/111/107/111107128/: by Prof. Kusumdeep, IIT Roorkee
3. https://nptel.ac.in/courses/112/106/112106134/: by Prof. G. Srinivasan, IIT Madras

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

CO1	Understand the queue and inventory model and solve related problems.
CO2	Create discrete random variable.
CO3	Generate continuous random variable and simulate queues and inventory models.
CO4	Understand and apply the variance reduction methods in simulation.
CO5	Test the goodness of a simulation by analyzing the simulated data.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	1	1								2	1	1
CO2	3	3	3	1	2								2	1	1
CO3	3	3	3	1	2								2	1	1
CO4	3	3	3	1	3								2	1	1
CO5	3	3	3	1	2								2	1	1

Type	Code	Entrepreneurship Development	L-T-P	Credits	Marks
OE	18BS3T20		3-0-0	3	100

Objectives	The objective of this course is to learn various aspects of becoming an entrepreneur by starting own business and making it successful so as to adopt entrepreneurship as a career option for graduating engineers.
Pre-Requisites	General knowledge of any business and its operations is sufficient.
Teaching Scheme	Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with real-life examples & case studies.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Concept and Overview: Concept of Entrepreneurship, The Entrepreneurial Process, Entrepreneurial Motivation, Developing Entrepreneurial Competencies, Characteristics of successful entrepreneur, Role of Entrepreneurship in Economic Development, Evolution and Growth of entrepreneurship in India.	**8 Hours**
Module-2	Ideas, Creativity, Innovation, Markets and Entrepreneurship: Ideas to Reality, Creativity, Innovation and Entrepreneurship, Identifying and recognizing Opportunities, Techniques for generating Ideas, Encouraging and Protecting the new ideas and selecting the right project, Ensuring your market, Market survey and Research.	**8 Hours**
Module-3	Business Plan: Meaning, Contents and significance of business plan, Formulation of business plan, Presentation of business plan to the investors, Techno-economic feasibility Assessment: A preliminary Project Report, The Detailed Project Report, Project Appraisal, Methods of Project Appraisal	**9 Hours**
Module-4	Financial Plan, and Marketing and Human Resource Management: Creating a successful financial plan, Source of financing, Institutional Finance to entrepreneurs, Basic financial statements, Ratio Analysis, Break-even Analysis. Problems of HRM and Relevant Labour laws, Marketing Management of Enterprises, Institutional support to entrepreneurs in Marketing.	**9 Hours**
Module-5	Intellectual Property: Concept and importance of Intellectual Property, Patents, Trade Mark, Copy rights, Trade secrets, Intellectual property audit, Start up: The Concept, Start up Policy of Government of India and Odisha in MSME sectors, Problems of MSME Sector, Sickness in MSMEs, Government policies on revival of sickness and remedial measures.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. B. R. Barringer and R. D. Ireland, ***Entrepreneurship***, 2nd Edition, Pearson Education, 2008.
T2. S. S. Khanka, ***Entrepreneurial Development***, 4th Edition, S. Chand & Co., 2010.

T3. Z. Thomas and S. Norman, ***Essentials of Entrepreneurship and Small Business Management***, 5th Edition, PHI Learning, 2009.

Reference Books:

R1. P. Chavantimath, ***Entrepreneurship Development and Small Business Enterprises***, 3rd Edition, Pearson Education, 2018.
R2. H. D. Robert and P. M. Shephard, ***Entrepreneurship***, 6th Edition, McGraw-Hill Education, 2007.
R3. P. C. Jain, ***Hand Book for New Entrepreneurs***, 4th Edition, Oxford University Press, 2004.
R4. J. A. Timmons and S. Spinelli Jr., ***New Venture Creation: Entrepreneurship for the 21st Century***, 8th Rev. Edition, Tata McGraw-Hill, 2009.
R5. R. Roy, ***Entrepreneurship Management***, 1st Edition, Oxford University Press, 2008.

Online Resources:

1. https://nptel.ac.in/courses/110/106/110106141/: by Prof. C. B. Rao, IIT Madras
2. https://nptel.ac.in/courses/127/105/127105007/: by Prof. M. K. Mondal, IIT Kharagpur
3. https://nptel.ac.in/courses/110/107/110107094/: by Prof. V. Sharma & Prof. R. Agrawal, IIT Roorkee

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

CO1	Describe the importance of entrepreneurship as a tool for development and discern distinct entrepreneurial traits.
CO2	Analyse the business environment to identify business opportunities and understand the systematic process to select and screen a business idea.
CO3	Prepare a proper business plan and project report.
CO4	Apply the tools necessary to create sustainable and viable businesses.
CO5	File and obtain patents for their innovative ideas to protect the rights of their business.

Program Outcomes Relevant to the Course:

PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						2			2		3	1		2	1
CO2						1			2		3	1		2	3
CO3						1	2		2		3	1		1	2
CO4						2	2		2		3	1		1	2
CO5						2	2		2		3	1		3	3

Type	Code	Satellite Communication Systems	L-T-P	Credits	Marks
OE	18EC3T21		3-0-0	3	100

Objectives	The objective of this course is to study modern satellite based communication systems for designing different downlinks, uplinks, along with preparation of link budgets to avoid signal outage for effective communications via satellites.
Pre-Requisites	Basics of analog & digital communication, and microwaves are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Architecture**: Principles and architecture of satellite communication, Brief history, advantages, disadvantages, applications, and frequency bands used for satellite communication. **Orbital Analysis**: Orbital equations, Kepler's laws of planetary motion, Apogee and Perigee for an elliptical orbit, evaluation of velocity, orbital period, angular velocity etc., of a satellite, Locating satellites with respect to earth, Look angles determination.	**9 Hours**
Module-2	**Satellite Sub-systems**: Architecture and roles of various sub-systems of a satellite system such as telemetry, tracking, command, and monitoring (TTC & M), Altitude and orbit control system (AOCS), Communication sub-system, Power sub-systems, Antenna sub-system, Equipment reliability, and space qualifications.	**8 Hours**
Module-3	**Typical Phenomena in Satellite Communication**: Solar Eclipse on satellite, its effects, remedies for Eclipse, Sun Transit Outage phenomena, its effects and remedies, Doppler frequency shift phenomena and expression for Doppler shift, Range variations and remedies, orbital perturbations.	**8 Hours**
Module-4	**Satellite Link Budget**: Flux density and received signal power equations, Calculation of System noise temperature for satellite receiver, noise power calculation, Drafting of satellite link budget and C/N ratio calculations in clear air and rainy conditions, Case study of Personal Communication system (satellite telephony) using LEO.	**9 Hours**
Module-5	**Modulation and Multiple Accessing Techniques**: Analog FM transmission by satellite, Digital transmission, TDM, FDMA, TDMA, CDMA, Typical case studies of VSAT, DBS-TV satellites, GPS.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. T. Pratt, C. Bostian, and J. Allnutt, ***Satellite Communications***, 2nd Edition, Wiley India, 2010.
T2. W. L. Pritchard, H. G. Suyderhoud, and R. A. Nelson, ***Satellite Communication Systems Engineering***, Pearson Education, 2003.

Reference Books:

R1. T. T. Ha, ***Digital Satellite Communications***, 2nd Edition, Tata McGraw-Hill, 2009.
R2. D. Roddy, ***Satellite Communications***, 4th Edition, Tata McGraw-Hill, 2008.
R3. A. K. Maini and V. Agrawal, ***Satellite Communications***, Willey, 2019.

Online Resources:

1. https://nptel.ac.in/courses/117/105/117105131/: by Prof. K. Bandyopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/101/105/101105077/: by Dr. M. Sinha, IIT Kharagpur
3. https://nptel.ac.in/courses/105/107/105107194/: by Prof. A. K. Saraf, IIT Roorkee

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

CO1	Describe the fundamentals and orbital mechanics of satellite communication systems.
CO2	Explain different satellite subsystems for effective communication.
CO3	Analyze and solve problems related to orbital effects of satellites.
CO4	Optimize practical satellite links considering various atmospheric propagation effects.
CO5	Analyze and optimize different modulation and MAC techniques in case studies.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2							1	2		1
CO2	3	3	3	2	3	1						1	3	1	1
CO3	3	3	3	2	3	1						1	3	1	1
CO4	3	3	3	2	3	2						1	3	1	1
CO5	3	3	3	2	2	2						1	3	1	1

Type	Code	Digital Image & Video Processing	L-T-P	Credits	Marks
OE	18EC3T30		3-0-0	3	100

Objectives	The objective of this course is to study the fundamentals, transformation, filtering, restoration, compression, and segmentation of images & videos, and their applications in various real life problems.
Pre-Requisites	Basics of matrices, 1-D convolution & filters, DSP, DFT, DCT, etc. are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Image Fundamentals**: Fundamental steps in digital image processing, Image sensing and acquisition, Image formation model. Image sampling and quantization, Spatial and intensity resolution, Image Interpolation, Relationship between pixels, Distance measure. **Basic Intensity Transformation Functions**: Image negative, Log transformation, Power-law transformations, Piecewise linear transformation functions, Contrast stretching, Intensity-level slicing, Bit-plane slicing, Histogram Processing, Histogram equalization.	**8 Hours**
Module-2	**Spatial & Frequency Domain Filters**: Mechanics of spatial filtering, Spatial correlation and convolution, Smoothing spatial filters, Sharpening spatial filters, Unsharp masking and high-boost filtering, Filtering in frequency domain, Image smoothing and sharpening in frequency domain using ideal, Butterworth, Gaussian, and Homomorphic filters.	**8 Hours**
Module-3	**Image Restoration**: A model of image degradation / restoration process, Noise models, Restoration in the presence of noise, Order statistics filters, Adaptive filters, Linear position invariant degradations, Estimating the degradation function, inverse filtering, Wiener filter, Constrained least square filter. **Color Image Processing**: Color fundamentals, Color models, Color conversions, Pseudo-color processing, Basics of full color image processing.	**8 Hours**
Module-4	**Image Segmentation**: Point, line and edge detection, Edge linking and boundary detection, Global processing using Hough transform, Thresholding, Global, adaptive and region-based segmentation. **Image Compression**: Fundamentals, Redundancy, Entropy, Some basic compression methods, Huffman coding, Arithmetic coding, LZW coding, Block transform coding, Predictive coding, Lossy predictive coding, Still image compression standards – JPEG and JPEG-2000.	**9 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	**Video Coding**: Inter-frame redundancy, Motion estimation techniques – full search, fast search, Forward and backward motion prediction, Frames, Slices, Macro-blocks and blocks, Frame classification – I, P and B; Video sequence hierarchy – Group of pictures; Elements of a video encoder and decoder; Video coding standards – MPEG and H.26X. **Video Segmentation**: Temporal segmentation – Shot boundary detection, Hard and Soft-cuts; Motion-based spatial segmentation; Video object detection & tracking.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. R. C. Gonzalez and R. E. Woods, ***Digital Image Processing***, 3rd Edition, Pearson Education, 2008.
T2. M. Tekalp, ***Digital Video Processing***, 2nd Edition, Prentice Hall of India, 2015.

Reference Books:

R1. A. K. Jain, ***Fundamentals of Digital Image Processing***, 2nd Edition, Prentice Hall of India, 2004.
R2. S. Sridhar, ***Digital Image Processing***, 2nd Edition, Oxford University Press, 2014.
R3. A. L. Bovik, ***A Handbook of Image and Video Processing***, 2nd Edition, Academic Press, 2000.
R4. S. Jayaraman, S. Esakkirajan, and T. Veerakumar, ***Digital Image Processing***, 2nd Edition, McGraw-Hill Education, 2013.

Online Resources:

1. https://nptel.ac.in/courses/117105079/: by Prof. P. K. Biswas, IIT Kharagpur
2. https://nptel.ac.in/courses/117105135/: by Prof. P. K. Biswas, IIT Kharagpur
3. https://nptel.ac.in/courses/106105032/: by Dr. G. Harit, IIT Kharagpur
4. https://nptel.ac.in/courses/117/104/117104069/: by Prof. S. Gupta, IIT Kanpur

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

CO1	Describe fundamental concepts of image processing, its scope and applications.
CO2	Explain 2D convolution in spatial & frequency domain and their implications in developing various high-pass & low-pass filters.
CO3	Restore images using various schemes & adaptive filters and process color images.
CO4	Segment and compress images using various techniques as per application requirement.
CO5	Perform video coding and segmentation using various techniques & standards.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

Cont'd...

PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	2	1	2							1	2		1
CO2	3	2	2	2	2							1	2		1
CO3	2	2	1	2	2							2	2		1
CO4	2	1	1	1	2							1	2		1
CO5	1	1	2	2	2							2	2		1

Type	Code	Robotics & Robot Applications	L-T-P	Credits	Marks
OE	18EC3T22		3-0-0	3	100

Objectives	The objective of this course is to learn the fundamental concepts of robotics, such as manipulators, kinematics, trajectory planning, control techniques, sensors etc., and basic robot programming for various industrial applications.
Pre-Requisites	Basics of Engineering Mathematics, Digital Electronics, Microprocessors & Microcontrollers, Automation & Control etc., are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on programming & applications.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Robot Fundamentals**: History of robotics, Basic concepts, Robot Anatomy, Robot Specification and work volume, Type of robot drives, Basic robot motions, Robot Manipulators, Kinematics, Precision movement.	**9 Hours**
Module-2	**End Effectors**: Introduction, Classification, Mechanical, Magnetic, Vacuum and Adhesive gripper, Gripper force analysis & design, Problem on gripper design and force calculation, Robot control - Unit control system concept, Servo & non-servo control of robot joints, Adaptive and optimal control.	**8 Hours**
Module-3	**Sensors**: Sensor devices, Types of sensors - contact, position and displacement sensors, force and torque sensors, Proximity and range sensors, Acoustic sensors, Robot vision systems - sensing and digitizing, Image processing and analysis.	**8 Hours**
Module-4	**Robot Programming**: Robot language, Classification, Programming methods, Lead through method, Teach pendent method, VAL systems and language, Simple program, Welding robot program, Program on loading/unloading.	**9 Hours**
Module-5	**Industrial Applications**: Application of robots, Material handling, Machine loading and unloading, Assembly robot, Inspection, Mobile robot, Microbots, Recent developments in robotics, safety considerations.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. R. Deb and S. Deb, ***Robotics Technology and Flexible Automation***, 2nd Edition, Tata McGraw-Hill, 2009.
T2. J. J. Crag, ***Introduction to Robotics: Mechanics and Control***, 3rd Edition, Pearson, 2004.
T3. S. K. Saha, ***Introduction to Robotics***, 2nd Edition, Tata McGraw-Hill, 2009.

Reference Books:

R1. R. K. Mittal and I. J. Nagrath, ***Robotics and Control***, 1st Edition, Tata McGraw-Hill, 2003.
R2. K. S. Fu, R. C. Gonzalez, and C. S. G. Lee, ***Robotics: Control, Sensing, Vision and Intelligence***, 1st Edition, McGraw-Hill, 1987.

R3. N. Odrey, M. Weiss, M. Groover, R. N. Nagel, and A. Dutta, ***Industrial Robotics: Technology, Programming and Application***, 2nd Edition, McGraw-Hill, 2012.

Online Resources:

1. https://nptel.ac.in/courses/112/107/112107289/: by Prof. N. Sukavanam and Prof. M. F. Orlando, IIT Roorkee
2. https://nptel.ac.in/courses/112/105/112105249/: by Prof. D. K. Pratihar, IIT Kharagpur
3. https://nptel.ac.in/courses/112/101/112101099/: by Prof. P. Seshu, Prof. P. S. Gandhi, Prof. K. K. Issac, Prof. B. Seth, and Prof. C. Amarnath, IIT Bombay

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

CO1	Describe robot fundamentals, drives, Manipulators, movements and kinematics.
CO2	Explain various classes of end effectors and robot control techniques.
CO3	Describe the working of sensors and vision systems and analyze the sensed data.
CO4	Write programs to make the parts of a robot function as per the needs.
CO5	Design & develop robots for various industrial applications in the real world.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	2	2							1	2		1
CO2	3	3	3	2	3	1						1	3	1	1
CO3	3	3	3	2	3	1						1	3	1	1
CO4	3	3	3	2	3	2						1	3	1	1
CO5	3	2	3	2	2	2	1					1	2	1	1

Type	Code	Industrial Instrumentation	L-T-P	Credits	Marks
OE	18EI3T25		3-0-0	3	100

Objectives	The objective of the course is to study the processes, characteristics, functionalities, instrument analysis, telemetry systems, and power plant instrumentation along with industrial hazards & safety considerations.
Pre-Requisites	Basic knowledge of Electronics, Electrical Engineering, Communication Engineering and Internet Technology is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on programming & applications.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Functional Units, Classification, Performance Characteristics, Dynamic Calibration, Errors: An Overview, Statistical Error Analysis, Reliability and related topics; **Transducers**: Pressure Transducers - Electrical and vacuum type - Pirani gauge, Thermocouple gauge, Ionization gauge, Flow meter - Turbo-magnetic, Electromagnetic, Ultrasonic type, Level sensor - Electrical type (contact & non-contact).	**10 Hours**
Module-2	**Instruments for Analysis**: Introduction, Gas Analysers, Liquid Analysers, X-ray Methods, Chromatography - Gas and Liquid, Nuclear Magnetic resonance spectroscopy, Electron spin resonance spectroscopy, Mass spectroscopy, Sampling techniques.	**9 Hours**
Module-3	**Telemetry**: Introduction, Pneumatic Means, Electrical Means - voltage, position and synchro transmitters & receivers, Frequency Telemetring, Multiplexing, Modulation, Modulation of Digital Data, Types of Transmission Channels and characteristic, Briefing of a Telemetry System in Operation, Wireless I/O.	**8 Hours**
Module-4	**Power Plant Instruments**: Introduction, The Power Plant Scheme, Pressure, Temperature, Flow and Level, Vibration and Expansion, Analysis - Conductivity, Silica, Sodium, pH, DO, Turbidity and Hydrazine, Flue Gas Analysis.	**8 Hours**
Module-5	**Hazards and Safety**: Initial consideration, Enclosures - NEMA type, IP type, Intrinsic Safety, Prevention of Ignition, Methods of Production, Analysis Evaluation and Construction - Intrinsically safe installation, Unbalanced and balanced schemes.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. D. Patranabis, ***Principle of Industrial Instrumentation***, 3rd Edition, McGraw-Hill, 2012.
T2. R. S. Khandpur, ***Handbook of Analytical Instruments***, 3rd Edition, Tata McGraw-Hill, 2015.

Reference Books:

R1. B. G. Liptak, ***Process Measurement and Analysis***, 3rd Edition, Chilton Book Company, 1995.
R2. J. P. Bentley, ***Principles of Measurement Systems***, 4th Edition, Pearson Education, 2005.
R3. A. K. Ghosh, ***Introduction to Instrumentation and Control***, 4th Edition, PHI Learning, 2012.
R4. D. Patranabis, ***Sensors and Transducers***, 2nd Edition, PHI Learning, 2010.
R5. D. V. S Murthy, ***Transducers and Instrumentation***, 4th Edition, PHI Learning, 2000.

Online Resources:

1. https://nptel.ac.in/courses/108/105/10810506/: by Dr.A. Barua, IIT Kharagpur
2. https://nptel.ac.in/courses/108/105/108105062/: by Prof. S. Mukhopadhyay and Prof. S. Sen, IIT Kharagpur
3. https://nptel.ac.in/courses/108/105/108105088/: by Prof. S. Mukhopadhyay, IIT Kharagpur

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

CO1	Describe the characteristics of instruments and uses of transducers in industry.
CO2	Identify the instruments for the analysis of chemical composition in industry.
CO3	Explain the principles & working of telemetry systems and their industrial applications.
CO4	Describe the various components of power plant instrumentation and its usage.
CO5	Realize hazards in industry and practice safety principles in instrumentation.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	1	2	1							1		
CO2	2	1	2	2	3		2						1		
CO3	2	2	2	2	2	1							1	1	2
CO4	2	3	2	2	1	2	1					1	1		
CO5	2	1	1	1	1	2	1	1					1	2	1

Type	Code	Soft Computing Lab	L-T-P	Credits	Marks
PC	18CS1L09		0-0-2	1	100

Objectives	The objective of this laboratory course is to get hands on practice on Soft Computing algorithms such as Fuzzy Logic, Genetic Algorithm, and Artificial Neural Networks using C programming language starting from fundamentals to complex real life problem solving.
Pre-Requisites	Knowledge of C programming and concepts of soft computing taught in the theory class are required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Write functions to generate the following parameterized fuzzy membership functions and visualize them for different parameter values: Triangular MF, Trapezoidal MF, Gaussian MF, Generalized Bell MF, Sigmoidal MF.
2	Write functions to implement following fuzzy complement operations on continuous membership functions and visualize them for different parameter values: Classical fuzzy complement, Sugeno's fuzzy complement, Yager's fuzzy complement.
3	Write functions to implement following fuzzy intersection operations (T-norms) on continuous membership functions and visualize them for different parameter values: Minimum, Algebraic product, Bounded product, Drastic product.
4	Write a function to compute the max-min composition of two fuzzy relations.
5	Write a function to compute the max-product composition of two fuzzy relations.
6	Demonstrate the effect of contrast intensification on a fuzzy membership function.
7	Write functions for implementing cylindrical extension of a 1D membership function and projection of a 2D membership function. Demonstrate the results visually.
8	Write programs to solve three unconstrained function optimization problems using Genetic Algorithm.
9	Write programs to solve three function optimization problems with constraint satisfaction using Genetic Algorithm.
10	Plot the graphs of different activation functions.
11	Implement AND, OR, XOR Gate using Single Layer Perceptron Neural Network.
12	Design a classifier using Multilayer Back propagation Neural Network to classify Iris data (UCI machine learning repository).

Text Books:

T1. D. K. Pratihar, ***Soft Computing***, Revised Edition, Narosa Publishing, 2015.
T2. J. S. R. Jang, C. T. Sun, and E. Mizutani, ***Neuro Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence***, 1st Edition, Pearson Education, 2015.
T3. S. Haykin, ***Neural Networks: A Comprehensive Foundation***, 2nd Edition, Pearson Education, 2006.

Reference Books:

R1. F. Martin, Mc Neill, and E. Thro, ***Fuzzy Logic: A Pratical Approach***, 1st Edition, AP Professional, 2000.
R2. T. J. Ross, ***Fuzzy Logic with Engineering Applications***, 3rd Edition, Wiley, 2010.
R3. N. K. Kasabov, ***Foundations of Neural Networks, Fuzzy Systems, and Knowldge Engineering***, 1st Edition, MIT Press, 1998.
R4. D. E. Goldberg, ***Genetic Algorithms In Search, Optimization and Machine Learning***, 1st Edition, Pearson Education, 2002.

Online Resources:

1. https://cse.iitkgp.ac.in/~dsamanta/courses/sca/resources/tutorials/PQ-FL-1.pdf

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

CO1	Investigate the behavior of different fuzzy membership functions.
CO2	Compute different composition of fuzzy membership functions for fuzzy modeling.
CO3	Design different inference engines for solving real life problems.
CO4	Train different ANN models for real life problem solving.
CO5	Develop different types of hybrid models for solving complex industrial problems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
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CO1	3	3	3	2								1	3	1	1
CO2	3	3	3	2								1	3	1	1
CO3	3	3	3	2								1	3	1	3
CO4	3	3	3	3								1	3	1	3
CO5	3	3	3	3								1	3	2	3