Annexure-IV

Eighth Semester

Open Elective-4

Sl. No.	Course Category	Course Code	Course Title	L	T	P	Contact Hours / week	Credit	Full Marks
1.	Open Elective - 4	OE CE 804	Geomatics Engineering	2	0	0	2	2	100
2.	Open Elective - 4	OE CS 804	Introduction to Data Analytics	2	0	0	2	2	100
3.	Open Elective - 4	OE EC 804	Basics Electronic Communication Engineering	2	0	0	2	2	100
4.	Open Elective - 4	OE EE 804	Industrial Power Safety Systems	2	0	0	2	2	100
5.	Open Elective - 4	OE ME 804	Principles of Management	2	0	0	2	2	100
6.	Open Elective - 4	OE CC 804	Engineering Geology	2	0	0	2	2	100
7.	Open Elective - 4	OE ES 804	Condition Monitoring of Electrical System	2	0	0	2	2	100
8.	Open Elective - 4	OE MI 804	Thermal Engineering	2	0	0	2	2	100

Geomatics Engineering

(Can be opted by students from all branches except CE and the students who had undergone similar course as program core or program elective)

Course Code	OE CE 804
Course Title	Geomatics Engineering
Number of Credits	2 (L: 2, T: 0, P: 0)
Prerequisites	Nil
Course Category	Open Elective (OE)
Number of classes	26 hours

Course Outcomes: After completion of the course students will be able to-

CO No	CO Description	K-level
CO-1	Demonstrate the concepts of Electro Magnetic energy, spectrum and spectral signature curves.	K-2
CO-2	Apply the concepts of satellite and sensor parameters and characteristics of different platforms.	K-3
CO-3	Apply the concepts of DBMS in GIS. Analyze raster and vector data and modelling in GIS.	K-3
CO-4	Apply GIS in land use, disaster management, ITS and resource information.	K-3

Course Contents:

Module 1: Introduction of Geomatics Engineering and its applications 7 Hours

Photogrammetry: aerial and terrestrial, applications of photogrammetry, types and geometry of aerial photograph, flying height and scale, relief (elevation) displacement. Stereoscopy: measurement and parallax and height determination, photogrammetric mapping.

Module 2: Remote Sensing 7 Hours

Basic remote sensing, interaction mechanism with atmospheric and earth surface, platforms and sensors. Data Products: Various remote sensing data products, high resolution and Hyperspectral images, visual data interpretation for information extraction.

Module 3: Digital Image Processing 6 Hours

Digital image, introduction to digital image processing, preprocessing, enhancement, classification, accuracy assessment. GPS surveying - principles and methods, DGPS, error in observations and corrections, Mapping with GPS.

Module 4: GIS **6 Hours**

Introduction of geographic information system (GIS), Vector and raster data, database creation, digital elevation model (DEM), Analysis in GIS. Applications: Applications in various engineering projects.

References / Suggested Learning Resources:

1. Agarwal, C.S. and Garg, P.K., "Remote Sensing in Natural Resources Monitoring and Management", Wheeler Publishing House. 2000
2. Bossler, J.D., "Manual of Geospatial Science and Technology", Taylor and Francis. 2002
3. Burrough, P.A. and McDonnell, R.A., "Principles of Geographic Information System", Oxford University Press. 2000
4. Chandra, A.M. and Ghosh, S.K., "Remote Sensing and Geographical Information Systems", Alpha Science. 2005
5. Gopi,S."Global Positioning System: Principles and Applications", Tata McGraw Hill. 2005
6. Lillesand, T.L., and Kiefer, R.W., "Remote Sensing and Image Interpretation, 4th Edition, John Wiley &Sons 2005

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Introduction to Data Analytics

(Can be opted by students from all branches except CSE and the students who had undergone similar course as program core or program elective)

Course Code	OE CS 804
Course Title	Introduction to Data Analytics
Number of credits	02(L: 2, T: 0, P: 0)
Prerequisites	Basic knowledge of Mathematics.
Course Category	Open Elective (OE)
Number of classes	26 hours

Course Outcome:

Course Outcomes (COs): At the end of the course, the student will be able to

CO Number	CO Description	K-level
CO-1	Understand the fundamentals of various data analytics techniques.	K2
CO-2	Implement machine learning techniques for solving practical problems.	K3
CO-3	Understand the concept of classification and regression.	K2
CO-4	Create big data for analytics through designed experiments.	K4

COURSE CONTENT

Module 1: (06 lectures)

Introduction to data analytics and Python fundamentals
Introduction to Descriptive Statistics, Probability Distributions,
Inferential Statistics, Inferential Statistics through hypothesis tests, Permutation & Randomization Test Regression & ANOVA Regression ANOVA(Analysis of Variance)

Module 2: (7 lectures)

Machine Learning: Introduction and Concepts, Differentiating algorithmic and model based frameworks Regression : Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbours Regression & Classification

Module 3: (7 lectures)

Supervised Learning with Regression and Classification techniques – Bias-Variance Dichotomy, Model Validation Approaches Logistic Regression Linear Discriminant Analysis Quadratic Discriminant Analysis Regression and Classification Trees Support Vector Machines
Ensemble Methods: Random Forest Neural Networks Deep learning

Module 4: (6 lectures)

Unsupervised Learning and Challenges for Big Data Analytics Clustering Associative Rule Mining Challenges for big data anlalytics, Prescriptive analytics Creating data for analytics through designed experiments Creating data for analytics through Active learning Creating data for analytics through Reinforcement learning

BOOKS AND REFERENCES

1. Hastie, Trevor, et al. The elements of statistical learning. Vol. 2. No. 1. New York: springer, 2009.
2. Montgomery, Douglas C., and George C. Runger.Applied statistics and probability for engineers. John Wiley & Sons, 2010
3. McKinney, W. (2012). Python for data analysis: Data wrangling with Pandas, NumPy, and IPython." O'Reilly Media, Inc.".
4. Swaroop, C. H. (2003). A Byte of Python. Python Tutorial.
5. Douglas C. Montgomery, George C. Runger (2002). Applied Statistics & Probability for Engineering. “John Wiley & Sons, Inc”

Basics Electronic Communication Engineering

(Can be opted by students from all branches except ECE and the students who had undergone similar course as program core or program elective)

Course Code	OE EC 804
Course Title	Basics Electronic Communication Engineering
Number of Credits	2 (L: 2, T: 0, P: 0)
Prerequisites	Basic Engineering knowledge
Course Category	Open Elective ECE (OE)
Number of classes	24 hours

Course Outcome:

At the end of this course students will demonstrate the ability to:

CO Number	CO Description	K-level
CO-1	Explain about amplitude modulation.	K2
CO-2	Explain about frequency and phase modulation.	K2
CO-3	Develop the understanding of noise in communication systems.	K3
CO-4	Explain about digital communication system, sampling, quantization, aliasing.	K2
CO-5	Develop the understanding of digital modulation techniques.	K3

Module 1: Introduction and Amplitude Modulation (06 Hours)

Basic communication system, Need for Modulation, Amplitude Modulation, Modulation Index, Spectrum of AM Signal, Introduction of Modulators and Demodulators, introduction of DSB, SSB, VSB Signals and its Spectrum, Balanced Modulator, Synchronous Detectors, Application of AM Systems.

Module 2: Frequency and Phase Modulation (06 Hours)

Phase and Frequency Modulation and their Relationship, Phase and Frequency Deviation, generation of FM and PM, Direct and Indirect method of Frequency Modulation, FM Demodulator, Pre-emphasis and De – emphasis, Comparison of FM, PM and AM.

Module 3: Noise in AM and FM Systems (04 Hours)

Sources of Noise, types of noise, noise parameters, Calculation of Noise in AM and FM systems, Comparison between AM and FM with respect to Noise.

Module 4: Introduction to Digital Communication (08 Hours)

Introduction to block schematic of digital communication system, sampling theorem. Quantization, quantization noise, linear and non-linear quantization, Companding, Aliasing effect. Pulse modulation, Pulse Amplitude and Pulse code modulation (PCM), Differential pulse code modulation. Introduction of Delta, adaptive delta and delta sigma modulation, Introduction of multiplexer, equalizer and filters. Concept of Time Division multiplexing and Frequency division multiplexing.

***TEXT/REFERENCE BOOKS*:**

1) Haykin S., "Communications Systems", John Wiley and Sons, 2001.
2) Proakis J. G. and Salehi M., "Communication Systems Engineering", Pearson Education, 2002.
3) Taub H. and Schilling D.L., "Principles of Communication Systems", Tata McGraw Hill, 2001.
4) Wozencraft J. M. and Jacobs I. M., ``Principles of Communication Engineering",John Wiley, 1965.
5) Barry J. R., Lee E. A. and Messerschmitt D. G., ``Digital Communication", Kluwer Academic Publishers, 2004.
6) Proakis J.G., ``Digital Communications", 4th Edition, McGr

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Industrial Power Safety System

(Can be opted by students from all branches except EE and the students who had undergone similar course as program core or program elective)

Course Code	OE EE-804
Course Title	Industrial Power Safety System
Number of Credits	2 (L: 2; T: 0; P: 0)
Prerequisites	Physics
Course Category	Open Elective (OE)
Number of Classes	26

Course Outcome: After Completion of this course students will able to

CO Number	CO Description	K-level
CO-1	Gather knowledge on basics of electrical fire and statutory requirements for electrical safety	K2
CO-2	Understand the causes of accidents due to electrical hazards	K2
CO-3	Know the importance of earthing and various protection system	K2
CO-4	Recognize different hazardous zones in Industries	K3

Module - I :INTRODUCTION (6 hours.)

General safety rules, principles, maintenance – Working principles of electrical equipment-Indian electricity act and rules-statutory requirements from electrical inspectorate-international standards on electrical safety – first aid-cardio pulmonary resuscitation (CPR).

Module II :ELECTRICAL HAZARDS (6 hours.)

Primary and secondary hazards-shocks, burns, scalds, falls-human safety in the use of electricity. Energy leakage-clearances and insulation-classes of insulation-voltage classifications-excess energy-current surges-Safety in handling of war equipments-over current and short circuit current-heating effects of current-electromagnetic forces-corona effect-static electricity – definition, sources, hazardous conditions, control, electrical causes of fire and explosion ionization, spark and arc-ignition energy-national electrical safety code ANSI. Lightning, hazards, lightning arrestor, installation – earthing, specifications, earth resistance, earth pit maintenance.

Module III: PROTECTION SYSTEMS (8 hours)

Fuse, circuit breakers and overload relays – protection against over voltage and under voltage – safe limits of amperage – voltage –safe distance from lines-capacity and protection of conductor-joints-and connections, overload and short circuit protection-no load protection earth fault protection. FRLS insulation-insulation and continuity test-system grounding-equipment grounding earth leakage circuit breaker (ELCB)-cable wires-maintenance of ground-ground fault circuit interrupter-use of low voltage-electrical guards-Personal protective equipment – safety in handling hand held electrical appliances tools and medical equipments.

Module-IV: HAZARDOUS ZONES (6 hours.)

Classification of hazardous zones -intrinsically safe and explosion proof electrical apparatus (IS, API and OSHA standard) -increase safe equipment-their selection for different zones temperature classification-grouping of gases-use of barriers and isolators-equipment certifying agencies. Working Around High Voltage Power Lines. Overhead and underground hazards.

TEXT BOOK

1. Fordham Cooper, W., “Electrical Safety Engineering” Butterworth and Company, London, 1986.
REFERENCES 1.”Accident prevention manual for industrial operations”, N.S.C.,Chicago, 1982.

2. Indian Electricity Act and Rules, Government of India.

3. Power Engineers – Handbook of TNEB, Chennai, 1989.

4. Martin Glov Electrostatic Hazards in powder handling, Research Studies Pvt.LTd., England, 1988

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Principles of Management

(Can be opted by students from all branches except ME and the students who had undergone similar course as program core or program elective)

Course Code	OE ME 804
Course Title	Principles of Management
Number of Credits	2 (L: 2, T:0, P: 0)
Prerequisites	Basic Engineering Knowledge
Course Category	Open Elective (OE)
Number of classes	26 hours

Course Outcome:

After successful completion of this course, the students will be able to

CO Number	CO Description	K Level
CO 1	Understanding the principles of management and their application to the functioning of an organization	**K2**
CO 2	Different aspects of work system design and facilities design pertinent to manufacturing industries	**K3**
CO 3	Understanding the role of productivity in streamlining a production system	**K4**
CO 4	Applying the inventory management tools in managing inventory	**K3**

Course Contents:

Module 1: Introduction: (5 Hours)

Definition of management, science or art, manager vs entrepreneur; Types of managers- managerial roles and skills; Evolution of management- scientific, human relations, system and contingency approaches;

Types of Business Organizations, sole proprietorship, partnership, company, public and private enterprises; Organization culture and environment; Current trends and issues in management. Nature and purpose of Planning, types of Planning, objectives, setting objectives, policies, Strategic Management, Planning Tools and Techniques, Decision making steps & processes.

Module 2: Nature and purpose of Organizing: (7 Hours)

Nature and purpose of Organizing, formal and informal organization, organization structure, types, line and staff authority, departmentalization, delegation of authority, centralization and decentralization, job design, human resource management, HR planning, Recruitment selection, Training & Development,

Performance Management, Career planning and Management.

Directing, individual and group behavior, motivation, motivation theories, motivational techniques, job satisfaction, job enrichment, leadership, types & theories of leadership, effective communication.

Module 3: Material Handling: **(8 Hours)**

Nature, Significance and Scope of Facility layout and design; Steps in facility layout planning, Assembly Line Balancing. Material Handling: Definition, Objective and Principles of Material Handling, Classification of Material Handling Devices. Controlling, system and process of controlling, budgetary and non-budgetary control techniques, use of computers and IT in management control, productivity problems and management, control and performance, direct and preventive control, reporting

Module 4: Inventory & Value Analysis: **(6 Hours)**

Importance and areas of materials management, Introduction to Inventory: Definitions, Need for inventory, Types of inventory, Inventory costs; Structure of inventory models, Deterministic models; safety stock, inventory control systems; Selective inventory management. MRP and JIT-based production systems, Concept of zero inventory, Fundamental concepts of purchasing, storing, distribution, and value analysis & engineering.

Text Books:

1. Robins S.P. and Couiter M., Management, Prentice Hall India, 10th ed., 2009.

2. Stoner JAF, Freeman RE and Gilbert DR, Management, 6th ed., Pearson Education, 2004. 3. Tripathy PC & Reddy PN, Principles of Management, Tata McGraw Hill, 1999.
3.C. Sharma, Industrial Engineering and Management, Khanna Book Publication, 2016.
4. O.P. Khanna, Industrial Engineering and Management, Dhanpat Rai Publication, 1980.
5. S. Ray, Introduction to Materials Handling, New Age International, 2016

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Engineering Geology

(Can be opted by students from all branches except CE&CA and the students who had undergone similar course as program core or program elective)

Course Code	OE CC 804
Course Title	Engineering Geology
Number of Credits	2 (L: 2, T: 0, P: 0)
Prerequisites	Geography
Course Category	Open Elective (OE)
Number of classes	26 hours

Course Outcome:

After completion of this course the students will be able to:

CO Number	CO Description	K-level
CO-1	Understand the weathering process, and superficial deposits and its geotechnical importance	K2
CO-2	Classify the geological formations	K2
CO-3	Analyze the geological hazards and preventing measures, and ground water with strength behaviour of rock	K4
CO-4	Apply geological principles for mitigation of natural hazards and select sites for dams and reservoir followed by sub surface investigation.	K3

Course Content:

Module 1: Physical Geology (06 hours)

Introduction-Branches of geology useful to civil engineering, scope of geological studies in various civil engineering projects. Mineralogy-Mineral, Origin and composition. Physical properties of minerals, basic of optical mineralogy, Rock forming minerals, megascopic identification of common primary & secondary minerals. Physical Geology- Weathering. Erosion and Denudation. Factors affecting weathering and product of weathering. Superficial deposits and its geotechnical importance: Water fall and Gorges, River meandering, Alluvium, Glacial deposits, Laterite (engineering aspects), Desert Landform, Loess, Residual deposits of Clay with flints, mudflows, Coastal deposits.

Module 2: Petrology (07 hours)

Petrology-Rock forming processes. Specific gravity of rocks. Igneous petrology- Volcanic Phenomenon and different materials ejected by volcanoes. Types of volcanic eruption. Characteristics

of different types of magma. Division of rock on the basis of depth of for mation and their characteristics. Chemical and Mineralogical Composition. Texture and its types. Various forms of rocks. Classification of Igneous rocks on the basis of Chemical composition. Detailed study of Acidic Igneous rocks like Granite, Rhyolite or Tuff, Felsite, Pegmatite, Hornfels. Engineering aspect to granite. Basic Igneous rocks Like Gabbro, Dolerite and Basalt. Engineering aspect to Basalt. Sedimentary petrology- mode of formation, Mineralogical Composition. Texture and its types, Structures, Gradation of Clastic rocks. Classification of sedimentary rocks and their characteristics. Detailed study of Conglomerate, Breccia, Sandstone, Mudstone and Shale, Limestone Metamorphic petrology- Agents and types of metamorphism, metamorphic grades, Mineralogical composition, structures & textures in metamorphic rocks. Important Distinguishing features of rocks as Rock cleavage, Foliation. Detailed study of Gneiss, Schist, Slate with engineering consideration.

Module 3: Geological Hazards and Ground Water with Strength Behavior of Rock (07 hours)

Geological Hazards- Rock Instability and Slope movement: Concept of sliding blocks. Different controlling factors. Instability in vertical rock structures and measures to prevent collapse. Types of landslides. Prevention by surface drainage, slope reinforcement by Rock bolting and Rock anchoring, retaining wall, Slope treatment. Ground water: Factors controlling water bearing capacity of rock. Pervious & impervious rocks and ground water. Lowering of water table and Subsidence. Earthquake: Magnitude and intensity of earthquake. Seismic sea waves. Seismic Zone in India.

Module 4: Geology of Dam and Reservoir, Mechanics of Rock (06 in hours)

Geology of dam and reservoir site- Required geological consideration for selecting dam and reservoir site. Failure of Reservoir. Favorable & unfavorable conditions in different types of rocks in presence of various structural features, precautions to be taken to counteract unsuitable conditions, significance of discontinuities on the dam site and treatment giving to such structures. Rock Mechanics- Sub surface investigations in rocks and engineering characteristics or rocks masses; Structural geology of rocks. Classification of rocks, Field & laboratory tests on rocks, Stress deformation of rocks, Failure theories and strength of rocks, Bearing capacity of rocks.

References / Suggested Learning Resources:

1. Engineering and General Geology, Parbin Singh, 8th Edition (2010), S K Kataria & Sons.

2. Text Book of Engineering Geology, N. Chenna Kesavulu, 2nd Edition (2009), Macmillan Publishers India.

3. Geology for Geotechnical Engineers, J.C.Harvey, Cambridge University Press (1982).

4. Principles of Engineering Geology, K.V.G.K. Gokhale, BS Publications, Hyderabad, 2005

5. Engineering Geology: Principles and Practice, David George Price, Springer, 2009

Condition Monitoring of Electrical System

(Can be opted by students from all branches except ECSE and the students who had undergone similar course as program core or program elective)

Course Code	OE ES 804
Course Title	Condition Monitoring of Electrical System
Number of Credits	2 (L: 2, T: 0, P: 0)
Prerequisites	Fundamentals of Electrical Machines, Electrical Measurements
Course Category	Open Elective.
Number of classes	26 hours

Course Outcome:

After completion of this course the students will be able to:

CO Number	CO Description	K-level
CO-1	Assess the condition of various electrical installations based on Insulation status.	K2
CO-2	Implement condition monitoring plan for complete Electrical System and machine	K3
CO-3	Identify amount of damage/deterioration in the Equipment and condition monitoring of transformer	K3
CO-4	Check the mechanical integrity of the equipment and monitoring of solar pv system, wind farm and cable	K4

Course Content:

Module 1: Maintenance and Condition Monitoring (6 Hours)

Importance and necessity of maintenance, different maintenance strategies like Breakdown maintenance, planned maintenance and condition based maintenance. Planned and preventive maintenance of transformer, induction motor and alternators. Insulation stressing factors, insulation deterioration, polarization index, dielectric absorption ratio. Insulation ageing mechanisms, Insulation failure modes, Condition monitoring by thermography.

Module 2: Condition Monitoring of Rotating Electrical Machines (7 Hours)

Condition Monitoring of Rotating Electrical Machines: Introduction, electric motor failures, simple preventive techniques, methods of motor monitoring such as current , temperature, starting strategies and soft starts,

resistance, lubrication, cleaning, general inspection, advanced techniques for electric generator monitoring, vibration monitoring, stator current monitoring.

Module 3: Transformer Diagnostics Technique (9 Hours)

Introduction, Transformer failure pattern and failure analysis, Aging of electrical Power infrastructure, Diagnostic method, Transformer oil paper insulation system, Remaining life analysis,

Conventional tests, Dissolved Gas Analysis, Gas Evolution in a Transformer, Key Gas method, IEEE Method, Gas Ratio Method, Fault Detectability using DGA, Combine Criteria for DGA,

Degree of Polymerization and Furan Analysis, Moisture analysis in Transformer Oil, Time domain Dielectric Response Methods, Polarization and depolarization current measurements, Frequency Domain Dielectric Frequency Response (DFR) Method, Introduction and Basic Philosophy, Advantages and Disadvantages of DFR measurement in Time and Frequency domain.

Module 4: Conditioning monitoring system of solar power plant, Wind farm, Cable (4 Hours)

Conditioning monitoring system of solar power plant**,** Operation and maintenance of wind farms, Essential elements of electrical cable condition monitoring program.

References / Suggested Learning Resources:

1. Kulkarni S. V. and Khaparde S. A., " Transformer Engineering – Design, Technology and Diagnostics" Second Edition, CRC Press, New York

2. T. S. Ramu and H N Nagamani, "Partial Discharge Based Condition Monitoring of High Voltage Equipment" New Age International, New Delhi

3. W. H. Tang and Q. H. Wu, "Condition Monitoring and Assessment of Power Transformers Using computation Intelligence", Springer, London 2010

4. Peter Tavner, Li Ran, Jim Penmanand Howard Sedding, "Condition Monitoring of Rotating Electrical Machines", Published by The Institution of Engineering and Technology, London, United Kingdom, 2008

5. Hamid A Toliyat, Subhasis Nandi, Seungdeog Choi, HomayounMeshgin-Kelk, " Electric Machines: Modeling, Condition Monitoring and Fault Diagnostics, CRC Press

6. Chakravorti Sivaji, DeyDebangshu, Chatterjee Biswendu, "Recent Trends in the Condition Monitoring of Transformers- Theory, Implementation and Analysis" Springer, 2013

7. Greg C. Stone, Edward A. Boulter, Ian Culbert, Hussein Dhirani, "Electrical Insulation for Rotating Machines: Design, Evaluation, Aging,Testing, and Repair", IEEE Press Series on Power Engineering, A John Wiley & Sons, Inc., Publication, 2004

8. R.E. James and Q. Su, "Condition Assessment of High Voltage Insulation in Power System Equipment", Published by The Institution of Engineering and Technology, London, United Kingdom, 2008.

Thermal Engineering

(Can be opted by students from all branches except AMIA and the students who had undergone similar course as program core or program elective)

Course Code	OE MI 804
Course Title	Thermal Engineering
Number of Credits	2 (L: 2, T: 0, P: 0)
Prerequisites	10+2 Physics
Course Category	Open Elective (OE)
Number of classes	26 hours

Course Outcomes:
After completion of the course, students will be able to:

CO No	CO Description	K-level
CO-1	Explain Thermodynamics Laws	K-2
CO-2	Calculate Available energy, efficiencies, power consumption of various thermo - dynamic cycles.	K-6
CO-3	Explain the concept of pure substances	K-2
CO-4	Explain the concept of basic heat transfer	K-2
CO-5	Calculate Available energy, efficiencies, power consumption of various thermo -dynamic power cycles	K-6

Course content:-

Module 1: **(6 Hours)**

Basic Concepts: Macroscopic and Microscopic Approaches, Thermodynamic Systems, Surrounding and Boundary, Thermodynamic Properties – Intensive and Extensive, Thermodynamic Equilibrium, State, Path, Process and Cycle, Quasi-static, Reversible and Irreversible Processes, Concept of Thermodynamic Work and Heat, Equality of Temperature, Zeroth Law of Thermodynamics and its utility. Numerical Problems. First Law of Thermodynamics: Energy and its Forms, Energy and 1st law of Thermodynamics, Internal Energy and Enthalpy, PMMFK, Steady Flow Energy Equation, 1st Law Applied to Non- Flow Process, Steady Flow Process and Transient Flow Process, Throttling Process and Free Expansion Process. Second Law of Thermodynamics: Limitations of First Law, Thermal Reservoir, Heat Source and Heat Sink, Heat Engine, Refrigerator and Heat Pump, Kelvin-Plank and Clausius Statements and their Equivalence, PMMSK. Carnot Cycle, Carnot Heat Engine and Carnot Heat Pump, Carnot Theorem and its Corollaries.

Module 2: **(6 Hours)**

Entropy: Introduction, Clausius Inequality, Principle of Entropy Increase, Temperature Entropy Plot, Entropy Change in Different Processes, Introduction to Third Law of Thermodynamics. Availability and Irreversibility: High and Low Grade Energy, Available and Unavailable Energy, Loss of Available Energy due to Heat Transfer through a Finite Temperature Difference, Helmholtz and Gibb's Functions, Availability of a Closed System, Availability of a Steady Flow System, Dead State of a System, Effectiveness and Irreversibility, Second law efficiencies of Processes & Cycles.

Module 3: **(6 Hours)**

Pure Substances and their Properties: Pure Substance and its Properties, Phase and Phase Transformation, Saturated and Superheat Steam, Triple point, T-V, P-V and P-T Plots During Steam Formation, Properties of Dry, Wet and Superheated Steam, Property Changes During Steam Processes, Temperature – Entropy (T-S) and Enthalpy – Entropy (H-S) Diagrams, Throttling and Measurement of Dryness Fraction of Steam. Thermodynamic Relations: Maxwell Relations, Relations for changes in Enthalpy and Internal Energy &Entropy, Specific Heat Capacity Relations, Clapeyron Equation, Joule Thomson coefficient & Inversion Curve.

Module 4: **(8 Hours)**

Introduction-Modes and mechanisms of heat transfer: Basic laws of heat transfer, General discussion about applications of heat transfer.Conduction Heat Transfer: Fourier rate equation, General heat conduction equation in Cartesian, Cylindrical and Spherical coordinates.
Simplification and forms of the field equation: steady, unsteady and periodic heat transfer, Initial and boundary conditions.

Power Cycles- Otto, Diesel, Dual Combustion cycles, Sterling Cycle, Atkinson Cycle, Ericsson Cycle, Joule Cycle – Description and representation on P–V and T-S diagram, Thermal Efficiency, Mean Effective Pressures on Air standard basis – compari son of Cycles. Refrigeration Cycles- Brayton and Rankine cycles – Performance Evaluation – combined cycles, Bell-Coleman cycle, Vapour compression cycle-performance Evaluation.

Text Book

1. Nag, P.K., "Engineering Thermodynamics", Tata McGraw-Hill.

2. YunusCengel& Boles, "Thermodynamics – An Engineering Approach", TMH.

3. Rajput, RK, "Thermal Engineering", Laxmi Publication.

4. Yadav, P., Fundamentals of Engineering Thermodynamics, Central Publishing.

5. Sonntag, R. E., Borgnakke, C., &Wylen, G. J. V., Fundamentals of thermodynamics: John Wiley.

6 Som, S. K., & Biswas, G. Introduction to fluid mechanics and fluid machines: Tata McGraw-Hill.
7. Kumar, D.S., Fluid Mechanics and Fluid Power Engineering, S.K.Kataria& Sons.

8. Cengel, Y., Fluid Mechanics, Tata McGraw-Hill.

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