ADITYA UNIVERSITY

Department of Mechanical Engineering

Ph.D. Course Work

(Applicable for the scholars admitted from the AY: 2025-26)

The credit requirement for the Ph.D. course work is a minimum of 12 credits including the courses on 'Research Methodology' and 'Research and Publication Ethics' for 2 credits each. The candidate must complete two domain-specific courses of 3 credits each, recommended by the respective Department Research Committee (DRC). These courses can be completed through MOOCs.

The candidate must present two research seminars before the completion of course work, typically within the first year. The first research seminar shall be before the end of first semester on introduction to the proposed research work, and the second seminar shall be before the end of the second semester or after the completion of course work on the research proposal, as per the format provided. Each research seminar will have one credit weightage. The course structure is presented in Table 1 and list of domain-specific courses is presented in Table 2.

Table 1: Course Structure

S. No.	Course Code	Name of the Course	Credit (s)
1	2517UC01	Research Seminar -I	1
2	2517UC02	Research Seminar -II	1
3	2517UC03	Research Methodology	2
4	2517UC04	Research and Publication Ethics	2
5	-	Domain Specific Course -I	3
6	-	Domain Specific Course -II	3
Total			**12**

Table 2: List of Domain - Specific Courses – I

S. No.	Course Code	Name of the Course
1.	2517ME01	Measurements in Thermal Engineering
2.	2517ME02	Gas Turbines and Jet Propulsion
3.	2517ME03	Energy Conservation & Waste Heat Recovery
4.	2517ME04	Heating, Ventilation and Air-Conditioning
5.	2517ME05	Convective Heat Transfer
6.	2517ME06	Renewable Sources of Energy
7.	2517ME07	Design of Heat Exchangers
8.	2517ME08	Combustion, Emissions and Environment
9.	2517ME09	Alternative Fuels
10.	2517ME10	Cryogenic Engineering
11.	2517ME11	Solar Energy Technologies
12.	2517ME12	Advanced Fuel Cell Technologies
13.	2517ME13	Advanced I.C. Engines
14.	2517ME14	Optimization Techniques & Applications
15.	2517ME15	Finite Element Method in Heat Transfer Analysis
16.	2517ME16	Solar Photovoltaics: Principles, Technologies & Materials
17.	2517ME17	Advanced Mechanics of Solids
18.	2517ME18	Mechanical Vibrations and Condition Monitoring
19.	2517ME19	Analysis And Synthesis of Mechanisms
20.	2517ME20	Experimental Stress Analysis
21.	2517ME21	Advanced Mechanical Design
22.	2517ME22	Advanced machining and micromachining processes
23.	2517ME23	Advanced Manufacturing Process
24.	2517ME24	Automation in Manufacturing
25.	2517ME25	Control of Robotic System
26.	2517ME26	Leading Edge Additive Engineering
27.	2517ME27	Fracture Mechanics
28.	2517ME28	Failure Analysis and Design
29.	2517ME29	Artificial Intelligence and Machine Learning for Mechanical Systems
30.	2517ME30	Advanced FEM and Simulation Techniques
31.	2517ME31	Data Analytics
32.	2517ME32	Quality and reliability
33.	2517ME33	Process Modelling and Optimization
34.	2517ME34	Robotic Mobility Systems
35.	2517ME35	Advanced Composite Materials
36.	2517ME36	Material Characterization
37.	2517ME37	Surface Engineering

Research Methodology

Course Code: 2517UC03

UNIT -I:
Research Design
Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys. Case Studies.

UNIT-II:
Data Collection and Sources
Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

UNIT-III:
Data Analysis and Reporting
Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

UNIT-IV:
Intellectual Property Rights
Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

UNIT-V:
Patents
Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licenses, Licensing of related patents, patent agents, Registration of patent agents.

Text Books:

1. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, Sage Publications, 4th Edition, 2015.
2. Intellectual Property: A Very Short Introduction, Siva Vaidhyanathan, Oxford University Press, 2017.
3. Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets" Deborah E. Bouchoux, Cengage India, 4th Edition, 2013.

Reference Books:

1. Research methodology: an introduction for science & engineering students, Stuart Melville and Wayne Goddard, Juta Academic, 2nd Edition, 2014.
2. Research design: Qualitative, quantitative, and mixed methods approaches, Creswell, J.W. and Creswell, J.D., Sage publications, 2017.
3. Intellectual Property in New Technological Age, Robert P. Merges, Peter S. Menell, Mark A. Lemley, Clause 8 Publishing; Volume I: Perspectives, Trade Secrets & Patents; 2023.

Web Links:

1. https://archive.nptel.ac.in/courses/121/106/121106007/#
2. https://onlinecourses.swayam2.ac.in/ntr24_ed08/preview

Research and Publication Ethics

Course Code: 2517UC04

Unit-I:
Philosophy & Ethics
Introduction to Philosophy:
Definition, Nature & Scope, Concept, Branches
Ethics:
Definition, Moral Philosophy, Nature of Moral Judgements & Reactions

Unit-II:
Scientific Conducts
Ethics with respect to Science and Research, Intellectual Honesty & Research Integrity
Scientific Misconducts:
Falsification, Fabrication & Plagiarism
Redundant Publications:
Duplicate & Overlapping Publication, Salami Slicing, SelectiveReporting & Misrepresentation of Data

Unit-III:
Publication Ethics:
Definition, Introduction and Importance
Best Practices/ Standard Setting Initiatives and Guidelines:
COPE, WAVE, etc., Conflictsof Interest
Publication Misconduct: Definition, Concept, Problems that lead to unethical behaviour and vice-versa, types, Violation of Publication Ethics, Authorship and Contributorship, Identification of Publication Misconduct, Complaints and Appeals, Predatory Publishers and Journals

Unit-IV:
Open Access Publishing
Open Access publications and Initiatives, SHERPA/ RoMEO online resource to check publisher copyright and self-achieving policies, Software tool to identify predatory publications developed by SPPU, Journal Finder/ Journal Suggestion tools viz. JANE, ELSEVIER, SPINGER, Journal suggester etc.

Unit-V:
Publication Misconduct Group Discussions:
Subject-specific Ethical issues, FFP, Authorship, Conflicts of Interest, Complaints and Appeals: Examples and fraud from India and Abroad
Software tools:
Use of Plagiarism software like Turnitin, Urkund and other open source software tools
Database and Research Metrics:
Database:
Indexing database, Citation database: web of science, Scopus etc.
Impact factor of journal as per journal citation report, SNIP, SJR, IPP, cite score
Metrics: h-index, g-index, i-10 index, AL metrics etc.

Text Books:

1. Philosophy in Science, Bird A, Routledge, 2006.
2. A Short History of Ethics, MacIntyre, London, 1967.

Reference Book:

1. Ethics in Science, Education and Governance, Indian National Science Academy, 2019.

Weblinks:

1. www.niehs.nih.gov/research/resources/bioethics/whatis
2. https://onlinecourses.swayam2.ac.in/nou22_ge73/preview

Measurements in Thermal Engineering

Course Code: 2517ME01

UNIT – I

Concept of Generalized Measurement System:

System configurations - Errors Problem analyses - Basic characteristics of measuring devices – Calibration. The transducer and its environment; an overview; sensing process and physical laws. Types of measurement problems. Transducer classification and their modeling; information, energy and incremental models

UNIT – II

Measurement of Pressure:

principles of pressure measurement, static and dynamic pressure, vacuum and high-pressure measurement – Measurement of low pressure, Manometers, Calibration methods, Dynamic characteristics, design principles. pressure Variable reluctance & LVDT Type pressure sensors – Knudsen gauge Thermal conductivity ionization gauge High pressure measurement – Piezo-electric and vibrating elements pressure sensors

UNIT – III

Flow measurement and Flow-Visualization methods, Positive displacement methods, Flow-obstruction methods, The sonic nozzle, Flow measurement by drag effect, Hot-wire and hot-film anemometers, Magnetic flow meters, Flow-visualization methods, The shadowgraph. The schlieren, The interferometer, The Laser Doppler Anemometer (LDA), Smoke method, Pressure probes and impact pressure in supersonic flow

UNIT – IV

Measurement of Temperature:

Thermo-electric sensors – Thermocouple & electrical resistance- Radiation & optical thermometers – Quartz crystal Thermometers – High speed Temperature probe

Errors in Measurement and its Analysis:

Causes and types of experimental errors; systematic and random errors. Uncertainty analysis; tion of overall uncertainty; estimation for design and selection for alternative test methods.

UNIT – V

Process Control:

Types of controllers - on/off, P, PI, PID controllers. Modeling of mechanical translation, rotary and simple hydraulic and pneumatic systems. Block diagrams, transfer functions and steady state behavior of systems. Dynamic behavior, stability criterion. Analog computer simulation of control systems. Discrete state process control. Introduction to digital control.

Text Books:

1 Experimental methods for engineers, J. P. Holman, McGraw Hill Education, 7th Edition,

2 Experimentation, validation, and uncertainty analysis for engineers, H.W. Coleman and W.G. Steele Jr, Wiley, 3d Edition

Reference Books:

1 Modern Control Engineering, M. Ogata, 4th Edition, Prentice-Hall,
2 Control Systems - Principles & Design, M. Gopal, TMH, 2nd Edition.

Web Links:

1 https://nptel.ac.in/courses/112103261
2 https://nptel.ac.in/courses/103105064

Gas Turbines and Jet Propulsion

Course Code: 2517ME02

UNIT – I

Thermodynamic cycle analysis of gas turbines;

open and closed cycles. Axial flow turbines; blade diagrams and design of blading, performance characteristics. The Gas Turbine Engine development for jet Propulsion; Jet engine performance parameters: Thrust, SFC, Efficiencies.

UNIT – II

Introduction to compressible fluid flow and control volume analysis

Coefficient of Compressibility - Stagnation state – Critical state - Various regions of flow Physical significance of Mach number - Mach cone - Differences between Incompressible and Compressible flows. Properties of atmosphere - Effect of Mach number on compressibility, Conservation laws for mass - Momentum and energy in steady flow.

UNIT – III

Shocks and Expansion waves in compressible flows, Flow with normal shock waves - Governing equations - Prandtl–Meyer equation - Impossibility of rarefaction shock - Mach number downstream of shock – Property variation across shock -Strength of shock wave - entropy change, Oblique shock-Property relations, Relation between Mx and My, θ-β-M relation, Maximum Value of Oblique shock, Detached shock, Prandtl-Meyer Expansion fans.

UNIT – IV

Aircraft Propulsion:

Air craft propulsion – Types of jet engines - Energy flow through jet engines - Thrust - Thrust power and Propulsive efficiency - Turbojet components - Diffuser compressor Combustion chamber - Turbines - Exhaust system - Performance of jet engines.

Rocket propulsion:

Rocket propulsion – Rocket engines - Basic theory of equation - Thrust effective jet velocity -Specific impulse - Rocket engine performance - Solid and Liquid propellant rockets – Comparison of various propulsion systems.

UNIT – V

Turbojet Engine:

Operation of a turbojet and afterburning turbojet engine Component analysis – intake and compressor combustor, turbine and nozzle. Turbofan engine-Turbofan engine - Component analysis – Fan Turbofan engine Emerging trends. Ramjet and turboramjet engines Operation of a Ramjet Engine and a Turboramjet Engine Ramjet and turboramjet engines Component analysis – Supersonic Intake.

Text Books:

1 Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion, Yahya.S.M, New Age International (P) Ltd, New Delhi, 3rd edition,

2 Gas Dynamics, Radhakrishnan.E, PHI Learning Pvt. Ltd, 4th edition,

Reference Books:

1 Elements of Propulsion: Gas turbines and Rockets, Mattingly.J.D, McGraw Hill.
2 Fundamentals of compressible fluid dynamics, Balachandran.P, PHI Learning.

Web Links:

1 https://archive.nptel.ac.in/courses/101/101/101101002/
2 https://soaneemrana.org/onewebmedia/GAS%20TURBINE%20AND%20JET%20&%20ROCKET%20PROPULSION1.pdf
3 https://www3.nd.edu/~powers/ame.40431/notes.pdf

Energy Conservation & Waste Heat Recovery

Course Code: 2517ME03

UNIT – I

Introduction to Waste Heat:

Importance of Waste Heat Recovery, Review of Thermodynamics – Introduction to First and Second Laws – Entropy, Entropy Generation, First and Second Law efficiency Power Plant Cycles - Energy Cascading, Rankine Cycle, modification of Rankine cycle, examples.

UNIT – II

Energy Conservation: Introduction:

Principles of thermodynamics: Rankine and Brayton cycles; enhancement of efficiency by reheat, regenerative, intercooling; topping, bottoming and combined cycles;

UNIT – III

Co-generation, Tri-generation & Boilers:

Definition, concept of tri generation; Cogenerations, Boilers: Types, Performance evaluation of boilers, Boiler Water Treatment and blow down, Introduction to FBC Boilers, Mechanism and Operational Features of FBC, Retrofitting FBC system to conventional boilers.

UNIT – IV

Waste Heat Recovery:

Classification, Advantages and applications, Selection criteria for waste heat recovery technologies, waste heat recovery devices: recuperators, regenerators, economizers, plate heat exchangers, thermic fluid heaters, Waste heat boilers-design aspects.

UNIT – V

Energy Storage Techniques

Pumped hydro, Compressed Air, Flywheel, Superconducting Magnetic storage Thermal storage (Sensible & Latent), Battery, Chemical Energy Storage, Fuel cells, Energy Economics.

Text Books:

1. Energy Storage, J Jensen, Elsevier.
2. Advance Energy Systems, Nikolai V. Khartchenko, Taylor and Francis Publishing, 2nd Edition.

Reference Books:

1. Powerplant Technology, M.M.El-Wakil, Tata McGraw Hill, Indian Edition.
2. Waste Heat Utilization and Management, Lee SS EDS, Seagate Subrata, Hemisphere, Washington.

Web Links:

1. https://archive.nptel.ac.in/courses/112/105/112105221/.
2. https://beeindia.gov.in/sites/default/files/2Ch8.pdf.
3. https://www.slideshare.net/slideshow/waste-heat-recovery-and-sustainable-energy-785c/266274018.

Heating, Ventilation and Air-Conditioning

Course Code: 2517ME04

UNIT – I

Introduction:

Brief history of air conditioning and its impact, HVAC systems and classifications, Heat pumps, Devices used in supply systems: Air inlet system, Filters heating & cooling equipment, Fans, Duct, Grills, Diffusers, Exhaust Systems: General exhaust systems, Local exhaust system, Removal of pollutants and contaminated air, Air cleaning devices.

UNIT – II

Ventilation System:

Indoor air quality, Need for ventilation, Effects of R.H. in building ventilation, Types of ventilation system-Exhaust Ventilation Systems, Supply Ventilation Systems, Balanced Ventilation Systems, and Energy Recovery Systems. Ventilation in Kitchen, Ventilation of Commercial Buildings: Design of commercial, Residential ventilation system.

UNIT – III

Psychrometry of Air Conditioning Processes:

Thermodynamic properties of moist air, Important Psychrometry properties, Psychometric chart; Psychrometric process in air conditioning equipment, applied Psychrometry, Psychrometric processes in air conditioning equipment, Bypass factor, air washers, Mixing, Heating and dehumidifying coils, Cooling by dry and wet coils, Use of hygroscopic solution in air washers, Adiabatic dehumidifiers. Humidifiers, Water injection, Steam injection.

UNIT – IV

Air Conditioning Systems:

Commercial, Residential and Industrial Air-Conditioning; Summer, Winter and Year round Air-Conditioning system, Comfort Air Conditioning: Thermodynamics of human body, metabolic rate, energy balance and models, thermoregulatory mechanism, Comfort & Comfort chart, Effective temperature, Factors governing optimum effective temperature, Design consideration, Selection of outside and inside design conditions.

UNIT – V

Heating and Cooling load calculations:

Sensible and latent heat loads, Sensible heat factor. Relationship between ESHF, ADP and BF, Recirculated air, Bypassed air and high latent heat load systems on Psychrometric chart, Cooling and heating load calculations, Selection of suitable air conditioning/ventilation system for different climate zones.

Text Books:

1 Refrigeration & Air Conditioning, Arora & Domkundwar, Dhanpat Rai & Co, 2018.
2 HVAC Simplified, S. P., Kavanaugh, American Society of Heating, Refrigerating and Air-Conditioning Engineers; Pap/Cdr edition.

Reference Books:

1 C.P. Arora, Refrigeration & Air Conditioning, TMH, 3rd Edition.
2 V. K. Jain, Refrigeration and Air Conditioning, Laxmi Publications Pvt. Ltd, 1st edition, 2019.
3 Hazim B. Awbi, Ventilation Systems: Design and Performance, Routledge, 1st edition.

Web Links:

1 https://archive.nptel.ac.in/courses/112/107/112107208/
2 https://archive.nptel.ac.in/courses/112/105/112105129/

Convective Heat Transfer

Course Code: 2517ME05

UNIT – I

Principles Of Convection:

Convection boundary layers, velocity boundary layers, thermal boundary layers, significance of boundary layers, laminar and turbulent flow, significance of dimensionless parameters, Reynold-Colburn analogy, drag & heat transfer.

UNIT – II

External Forced Convection:

Parallel flow over flat plate, flow errors Cylinders and spheres, flow across tube banks (aligned and staggered), correlations for all the mentioned cases.

UNIT – III

Internal Flow:

Hydrodynamic considerations, flow conditions, velocity profiles in fully developed regions, laminar flow inside tubes, turbulent flow in tubes, bulk temperature flow through tube annulus, correlations related to mentioned cases, convection correlations for Non circular tubes, heat transfer enhancement.

UNIT – IV

Natural Convection:

Equations of motions, Grashof's number, natural convection over surfaces, Plates, Cylinders, Spheres (all cases), natural convection inside enclosures, combined free and forced convection, correlations related to mentioned cases.

UNIT – V

Heat Exchangers:

Design of Parallel flow, Counter flow, Cross flow, Multipass-cross flow, Heat exchangers, LMTD, method design, effectiveness-NTU method, compact heat exchangers, heat exchanger optimization.

Text Books:

1 Heat transfer, J.P. Holman, McGraw Hill Education, 10th edition.
2 Fundamentals of heat transfer, Dewitt Incopera, John Wiley & Sons, 6th edition.

Reference Books:

1 Fundamentals of Engineering Heat and Mass Transfer, R.C Sachdeva, New Age International Private Limited, 6th edition 2022.
2 Convective Heat Transfer, Kays & Crawford, McGraw-Hill Education, 3rd edition.

Web Links:

1 https://onlinecourses.nptel.ac.in/noc24_me07/preview.
2 https://www.engineeringtoolbox.com/convective-heat-transfer-d_430.html.

Renewable Sources of Energy

Course Code: 2517ME06

UNIT – I

Introduction to Renewable energy sources:

Energy demand and availability, energy crisis, renewable and non-renewable energy resources, environmental impact of conventional energy usage.

Solar Energy:

Overview of the fundamental physics of solar radiation, radiation measurement. Solar energy collectors., Solar thermal power plant, Classification of solar thermal plant, Central receiver power plant, solar pond etc, basic principle of SPV conversion, Types of PV system and solar cells. Solar Applications- Solar heating and cooling technique, Solar distillation and drying, Photovoltaic energy conversion

UNIT – II

Wind Energy:

Wind, Beaufort number, Characteristics, Wind energy conversion systems, Types, Betz model. Interference factor. Power coefficient, Torque coefficient and Thrust coefficient, lift machines, and Drag machines. Matching, Electricity generation.

UNIT – III

Biomass:

Bio resources, Conversion process, Biomass gasifier - Types of biomass gasifiers, Biodiesel production – Ethanol production -Applications.

Geothermal Energy:

Origin and types of geothermal energy and utilisation, Power generation from Geothermal energy, Environmental impact.

UNIT – IV

Ocean, Wave & Tidal Energy:

Introduction - Resource Assessment - Power generation through OTEC systems. Wave and Tidal energy Fundamentals, Availability, and energy conversion systems.

Direct Energy Conversion:

Nuclear Fusion, Fusion, Fusion reaction, P, P cycle, Carbon cycle, Deuterium cycle, Condition for controlled fusion, Fuel cells and photovoltaic. Thermionic & thermoelectric generation, MHD generator.

UNIT – V

Hydrogen Gas as Fuel:

Production methods, Properties, I.C. Engine applications, Utilization strategy, Performance.

Hybrid Energy Systems:

Systems for processes and power applications – solar – wind – Biomass hybrid technologies.

Text Books:

1 Non-Conventional Energy Resources, B H Khan, TMH Publishers, 3rd Edition,

2 Renewable Energy: Power for a Sustainable Future, Boyle, G, Oxford University Press, 3rd Edition,

Reference Books:

1 Non-Conventional Energy Sources, G.D.Rai, Khanna Publishers, 6th edition
2 Renewable Energy Resources, John Twidell, Tony Weir, and Anthony D. Weir, Taylor & Francis,

Web Links:

1 https://onlinecourses.nptel.ac.in/noc22_ch27/preview
2 https://www.energy.gov/eere/renewable-energy

Design of Heat Exchangers

Course Code: 2517ME07

UNIT – I
Introduction:
Classification of Heat Exchangers - Heat Transfer Mechanisms - Flow Arrangements - Applications - Selection of Heat Exchangers. LMTD and NTU Method for heat exchanger analysis - Heat exchanger design methodology

UNIT – II
Stress Analysis:
Effect of turbulence – friction factor – pressure loss – stress in tubes – header sheets and pressure vessels – thermal stresses, shear stresses –types of failures.

UNIT – III
Design Aspects:
Heat transfer and pressure loss – flow configuration – effect of baffles – effect of deviations from ideality – design of double pipe – finned tube – shell and tube heat exchangers – simulation of heat exchangers

UNIT – IV
Compact and Plate Heat Exchangers:
Types–merits and demerits–design of compact heat exchangers, plate heat exchangers–performance influencing parameters– limitations.
Condensers and Cooling Towers:
Design of surface and evaporative condensers–cooling tower –performance characteristics

UNIT – V
Optimum Design:
Criteria for optimisation of heat exchangers, constraints, feasible and optimum design, optimization based on volume, weight, cost, entropy generation and thermoeconomics; Brief introduction to some traditional and non-traditional optimisation techniques.

Text Books:
1. Heat transfer: A Practical Approach, Yonous A. Cengel,McGraw Hill.
2. Heat Exchangers: Selection, Rating, and Thermal Design, Sadik Kakaç, Hongtan Liu, Anchasa Pramuanjaroenkij, CRC Press, 4th Edition, 2020.

Reference Books:
1. Handbook of Heat Transfer, Warren Rohsenow, James Hartnett, Young Cho, McGraw Hill, 3rd Edition.
2. Fundamentals of Heat Exchanger Design, RH. Shah, John Wiley & Sons Inc, 1st Edition.

Web Links:
1. https://archive.nptel.ac.in/content/storage2/courses/103103027/pdf/mod1.pdf
2. https://inldigitallibrary.inl.gov/sites/sti/sti/5901289.pdf
3. https://onlinecourses.nptel.ac.in/noc20_me52/preview

Combustion, Emissions and Environment

Course Code: 2517ME08

UNIT – I

Principles of Combustion:

Chemical composition, Flue gas analysis, dew point of products, Combustion stoichiometry, Chemical kinetics, Rate of reaction, Reaction order, Molecularity, Zeroth, first, second and third order reactions, complex reactions, chain reactions, Theories of reaction Kinetics, General oxidation behavior of HCs.

UNIT – II

Thermodynamics of Combustion:

Enthalpy of formation, Heating value of fuel, Adiabatic flame Temperature, Equilibrium composition of gaseous mixtures.

UNIT – III

Laminar and Turbulent Flames Propagation and Structure:

Flame stability, burning velocity of fuels, Measurement of burning velocity, factors affecting the Burning velocity. Combustion of fuel droplets and sprays, Combustion systems, Pulverized fuel furnaces- fixed, entrained and fluidized bed systems.

UNIT – IV

Pollution Formation Measurement and Control:

Causes for Formation of NOx, SOx, COx, Smoke and UBHC. Different methods of measurement of pollutants. methods of controlling the formation of pollutants, BHARAT and EURO standards of emissions**.**

UNIT – V

Environmental Considerations:

Air pollution, effects on environment, human health etc. Principal pollutants, Legislative measures, methods of emission control.

Text Books:

1 Sharma and Chandra Mohan, Fuels and combustion, Tata McGraw Hill.
2 Shaha A.K., Combustion Engineering and Fuel Technology, Oxford and IBH.

Reference Books:

1 Principles of Combustion, Kanneth K.Kuo, Wiley and Sons.
2 An Introduction to Combustion, Stephen R. Turns, Mc. Graw Hill International 4th Edition, 2020.

Web Links:

1 http://nptel.ac.in/courses/107106080/.
2 http://www.engineering108.com/Data/Engineering/Automobile/advance-vehicle echnology.pdf.
3 http://nptel.ac.in/112999903.

Alternative Fuels

Course Code: 2517ME09

UNIT – I

Liquid Fuels: Alcohols:

Properties, production, advantages and disadvantages of Methanol and Ethanol and their blends as fuel for SI and CI engine.

Biodiesels:

Background of Diesel/Biodiesel fuels-Oil feed stocks-Transesterification-Biodiesel production from Vegetable oils. Properties of biodiesel and their importance in the context of performance and emissions of IC Engines.

Recycled Fuels :

Pyrolysis- plastic, tyre and cooking oils.

UNIT – II

Gaseous Fuels: Hydrogen:

Introduction, properties and production of hydrogen. Storage, Advantages and disadvantages of hydrogen as fuel for SI and CI engines. Hazards and safety systems for hydrogen, hydrogen combustion. Performance and emission of from hydrogen.

Other Gaseous Fuels:

Properties, production, advantages and disadvantages of LPG, CNG, Bio gas as fuel for SI and CI engines.

UNIT – III

SI Engine Emissions and its Control:

Emission formation in SI Engines- Carbon monoxide & Carbon dioxide - Unburned hydrocarbon, NOx, Smoke-Effects of design and operating variables on emission formation-controlling of pollutants - Catalytic converters, Charcoal Canister, Positive Crank case ventilation system, Secondary air injection.

UNIT – IV

CI Engine Emission and its Control:

Emission formation in CI Engines- Carbon monoxide & Carbon dioxide - Unburned hydrocarbon, NOx, soot, particulate matter and Intermediate Compounds - Physical and Chemical delay- Significance Effect of operating variables on Emission formation-Fumigation, Split injection, Catalytic Coating, EGR, HCCI, Particulate Traps, SCR.

UNIT – V

Test Procedures and Emission Measurements:

Emission test cycles, constant volume sampling method, non-dispersive infrared (NDIR) analyzer, flame ionization detectors (FID), chemiluminescence analyzer, smoke meters, gas chromatograph.

Text Books:

1 Alternate Fuels, S. S. Thipse, Jaico Publications

2 IC Engine Combustion & Emissions by B.P. Pundir, 4th Edition, Narosa Publications, 2020.

Reference Books:

1 Alternative Fuels Guidebook, Richard L.Bechtold, Society of Automotive Engineers (SAE),

2 Internal Combustion Engines Fundamentals, John B. Heywood, Mc Graw Hill Publications, 2nd Edition, 2018.

Web Links:

1 https://archive.nptel.ac.in/content/storage2/courses/112104033/lecture39.

2 https://nptel.ac.in/courses/112104033.

3 https://www.udemy.com/course/automotive-engineering-automobile-fundamentals-and-advanced/?couponCode=LEADERSALE24A.

Cryogenic Engineering

Course Code: 2517ME10

UNIT – I
Introduction:
Historical background, Insight on Cryogenics, Definition and Engineering applications of Cryogenics, Properties of solids for cryogenic systems, Properties of Cryogenic fluids, Material properties at Cryogenic Temperatures, Mechanical properties, Thermal properties, Electrical and Magnetic Properties, Present area involving cryogenics.

UNIT – II
Gas-Liquefaction System:
Carnot liquefaction cycle, F.O.M, and Yield of liquefaction Cycles, Joule-Thomson effect, Adiabatic expansion, Simple Linde-Hampson system, Precooled Linde- Hampson system, Linde dual-pressure system, Cascade system, Claude system, Kapitza system, Collins helium liquefaction system, Ortho-Para hydrogen conversion, Critical components in liquefaction systems.

UNIT – III
Binary Mixtures:
T-C and H-C Diagrams, Principle of Rectification, Rectification Column Analysis - McCabe Thiele Method, Adsorption Systems for purification.
Cryogenic Storage and transfer Systems: Cryogenic fluid storage vessels, insulations, cryogenic transfer systems.

UNIT – IV
Cryogenic Refrigeration System:
Philips refrigerator, Importance of regenerator effectiveness for Philips refrigerator, Gifford-McMohan refrigerator, J. T. Cryocoolers, Stirling Cycle Refrigerators, Pulse Tube Refrigerators, Regenerators used in Cryogenic Refrigerators, Magnetic Refrigerators.

UNIT – V
Vacuum Technology:
Introduction and importance of vacuum technology in cryogenics, Flow regimes in vacuum systems, Conductance in vacuum systems, Operation of vacuum pumps, Calculation of pump-down time for a vacuum systems, Components of a vacuum systems, Mechanical vacuum pumps, Diffusion pumps, Ion pumps, Cryopumping. Vacuum gauges and valves.

Text Books:

1 Fundamentals of Cryogenic Engineering, Mamata Mukhopadhyay, PHI Learning,
2 Cryogenic Engineering, Thomas Flynn, CRC Press, 2nd edition, 2020.

Reference Books:

1 Cryogenic Technology and Applications, A. R. Jha, Butterworth-Heinemann, 1st edition.
2 Cryogenic Mixed Refrigerant Processes, Gadhiraju Venkatarathnam, Springer-Verlag New York Inc.
3 Cryogenic Engineering: Fifty Years of Progress, Timmerhaus et. al., Springer, 2020.

Web Links:

1 https://nptel.ac.in/courses/112101004
2 https://www.slac.stanford.edu/econf/C0605091/present/CERN.PDF

Solar Energy Technologies

Course Code: 2517ME11

UNIT – I

Introduction:

Solar energy option, specialty, and potential, Solar radiation, beam and diffuse – measurement, estimation of average solar radiation on horizontal and tilted surfaces, problems, applications. Capturing solar radiation – physical principles of collection, types – liquid flat plate collectors – construction details performance analysis – concentrating collection, flat plate collectors with plane reflectors, cylindrical parabolic collectors, Orientation and tracking Performance Analysis

UNIT – II

Design of Solar Water Heating System and Layout:

Power generation –solar central receiver system – Heliostats and Receiver – Heat transport system – solar distributed receiver system – Power cycles, working fluids and prime movers, concentration ratio.

UNIT – III

Thermal Energy Storage:

Introduction – Need for – Methods of sensible heat storage using solids and liquids – Packed bed storage – Latent heat storage – working principle – construction – application and limitations. Other solar devices – stills, air heaters, dryers, Solar Ponds & Solar Refrigeration, active and passive heating systems.

UNIT – IV

Direct Energy Conversion:

Solid state principles, semiconductors, solar cells performance, modular construction – applications. conversion efficiencies calculations

UNIT – V

Economics:

Principles of Economic Analysis – Discounted cash flow – Solar system, life cycle costs – cost benefit analysis and optimization – cost-based analysis of water heating and photo voltaic applications.

Text Books:

1 Solar Energy-Principles of Thermal Collection and Storage, S P Sukhatme & J K Nayak, McGraw Hill Education, 3rd Edition

2 Principles of Solar Engineering, D.Yogi Goswami, Frank Krieth and Jan F. Kreider Taylor and Francis, USA. 2nd Edition,

Reference Books:

1 G.N.Tiwari, Solar Energy- Fundamentals, Design, Modelling and Applications, Narosa publishing house. 6th edition

2 Domkundwar, Solar Energy and Non-conventional Energy Sources, Dhanpat Rai & Co, (P) Ltd., Revised 2nd edition.

Web Links:

1 https://archive.nptel.ac.in/courses/115/103/115103123/.
2 https://www.nrel.gov/research/re-solar.html.

Advanced Fuel Cell Technologies

Course Code: 2517ME12

UNIT – I
Introduction:
Hydrogen – physical and chemical properties, salient characteristics. Production of hydrogen – steam reforming – water electrolysis – biological hydrogen production –direct thermal or catalytic splitting of water.

UNIT – II
Storage:
Hydrogen storage options – Compressed gas – Liquid hydrogen – Chemical Storage – comparisons. Safety and Management of Hydrogen. Applications of Hydrogen.

UNIT – III
Fuel Cell:
Fuel Cells as Electrochemical Engines, Generic Fuel Cell and Stack, Classification of Fuel Cells, Potential Applications, History of Fuel Cell Development.

UNIT – IV
Types of Fuel Cell:
Alkaline Fuel Cells, Molten Carbonate Fuel Cells, PEM Fuel Cells, Solid Oxide Fuel Cells, Phosphoric acid Fuel Cells, Microbial Fuel Cells, Regenerative Fuel Cells.

UNIT – V
Usage of Fuel Cell:
Fuel cell usage for domestic power systems, large scale power generation, Automobile, Space. Economic and environmental analysis on usage of Hydrogen and Fuel cell. Future trends in fuel cells.

Text Books:

1. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma.
2. Barclay F.J., Fuel Cells, Engines and Hydrogen, Wiley.

Reference Books:

1. Viswanathan B. and Aulice Scibioh.M, Fuel Cells – Principles and Applications, Universities Press.
2. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma.

Web Links:

1. https://archive.nptel.ac.in/courses/103/102/103102015/
2. https://archive.nptel.ac.in/content/storage2/courses/112104033/lecture40/40_5.htm

Advanced I.C. Engines

Course Code: 2517ME13

UNIT – I
Gas Exchange Processes:
Inlet and exhaust processes in the four stroke cycle volumetric efficiency quasi static effects combined quasi static and dynamic effects variation with speed and valve area and timing-flow through valves poppet valve geometry and timing flow rate and discharge efficient, residual gas fraction exhaust gas flow rate and temperature variation, scavenging in wnike eyelid engines,

UNIT – II
Charge Motion Within The Cylinder:
Intake Jet Flow, Mean velocity and turbulence characteristics definitions application to engine velocity data swirl swirl measurement, swirl generation during induction swit modification within the cylinder

UNIT – III
Combustion In S.I And C.I Engines:
Review of normal and abnormal combustion in SI and CI engine cyclic variation in combustion of St engine analysis of cylindrical pressure data in SI and CI engine.

UNIT – IV
Electric Vehicles:
Introduction Limitations of IC Engines as prime mover. History of EV, EVem. components of V. and AC electric machines: Introduction and basic structure, Batteries: Battery lead acid battery, cell discharge and charge operation, construction advantages of lead, acid battery,

UNIT – V
Fuel Cell Vehicles:
Introduction, Fuel cell characteristics, Thermodynamics of Fuel cells, Fuell cell types; emphasis on PEM fuel cell.

Text Books:
1 J.B. Heywood, Internal Combustion Engine Fundamentals, Mc Graw Hill Co.
2 Seth Leitman and Bob Bran, Build your own electric vehicle, McGraw Hill, Co, 3rd edition.

Reference Books:
1 H.N. Gupta, Engineering Fundamentals of IC Engine, 2nd edition, PHI Pvt. Ltd.
2 F. Barbir, PEM Fuel Cells-Theory and Practice, Academic Press.

Web Links:
1 http://nptel.ac.in/courses/112101097/.
2 www.thermopedia.com/content/786.

Optmization Techniques & Applications

Course Code: 2517ME14

UNIT – I
Single Variable Non-Linear Unconstrained Optimization:
One dimensional Optimization methods:, Uni modal function, elimination methods, Fibonacci method, golden section method, interpolation methods, quadratic & cubic interpolation methods.

UNIT – II
Multi Variable Non-Linear Unconstrained Optimization:
Direct search method, Univariant method, pattern search methods, Powell's, Hook, Jeeves, Rosen brock search methods, gradient methods, gradient of function, steepest decent method, Fletcher Reeves method, variable metric method.

UNIT – III
Linear Programming:
Formulation, Sensitivity analysis. Change in the constraints, cost coefficients, coefficients of the constraints, addition and deletion of variable, constraints. Duality, importance of duality, solution of primal from dual.

UNIT – IV
Non-Traditional Optimization Algorithms:
Genetics Algorithm, Working Principles, Similarities and Differences between Genetic Algorithm & Traditional Methods. Simulated Annealing, Working Principle, Simple Problems.

UNIT – V
Applications To Thermal Systems:
Optimal design of heat exchangers, condensers, evaporator and IC Engines.

Text Books:
1 Optimization theory & Applications, S.S. Rao, New Age International, 4th edition.
2 Optimization for Engineering Design, Kalyanmoy Deb, PHI.

Reference Books:
1 Operations Research S.D. Sharma, Kedarnath Publishers.
2 Optimization Techniques, Benugundu & Chandraputla, Pearson Asia.
3 Design of Thermal Systems, W.F Stoecker, Mc Graw Hill Education, 3rd edition.

Web Links:
1 http://nptel.ac.in/downloads/112101004/.
2 https://home.cern/about/engineering/cryogenics-low-temperatures-highperformance.

Finite Element Method in Heat Transfer Analysis

Course Code: 2517ME15

UNIT – I

Finite element modelling coordinates and shape functions:

Assembly of Global stiffness matrix and load vector. Finite element equations, Treatment of boundary conditions, Quadratic shape functions. Analysis of Trusses: Introduction, analysis of plane trusses, local and global stiffness matrix, treatment of boundary conditions, solutions, temperature effects. Analysis of Beams: Formulation, load vector, boundary conditions, shear force and bending moment, solutions.

UNIT – II

Higher order and Isoparametric elements:

One dimensional quadratic and cubic elements in natural coordinates, two dimensional four noded isoparametric elements and numerical integration. Steady State Heat Transfer Analysis: One dimensional analysis of conduction, convection problems.

UNIT – III

Finite element analysis of 1-D problems:

formulation by different approaches (direct, potential energy and Galerkin), Derivation of elemental equations and their assembly. Applications in heat transfer, fluid mechanics and solid mechanics. Bending of beams, analysis of truss and frame.

UNIT – IV

Finite element analysis of 2-D problems:

finite element modelling of single variable problems, triangular and rectangular elements, Applications in heat transfer, fluid mechanics.

UNIT – V

2-D problem for Plane stress and plane strain problems:

Bending of plates; Eigen value and time dependent problems; Discussion about pre-processors, postprocessors and finite element package ANSYS.

Text Books:

1. Introduction to Finite Elements in Engineering, T.R. Chandrupatla and A.D. Belegundu, PHI publications, 4th edition.
2. A First Course in the Finite Element Method, Daryl L. Logan, Cengage Learning India Private Limited, 6th edition.

Reference Books:

1. An Introduction to the Finite Element Method, J.N. Reddy, McGraw Hill Education, 4th edition, 2020.
2. Concepts and Applications of Finite Element Analysis, Cook et al, Wiley Publications, 4th edition.

Web Links:

1. https://nptel.ac.in/courses/112/104/112104193/
2. https://nptel.ac.in/courses/112/104/112104205/

Solar Photovoltaics: Principles, Technologies & Materials

Course Code: 2517ME16

UNIT – I
Introduction and Solar radiation fundamentals
Introduction to Solar Energy, Solar Radiation, Atmospheric Effects on Solar Radiation, Effects of Location on Time, Sun-Earth Angular Relation, Solar Radiation Measurements

UNIT – II
Basic physics of semiconductors & Carrier transport, generation and recombination in semiconductors
Introduction to Band Theory, Semiconductor Basics-I, Semiconductor Basics-II, Electrical Properties of Semiconductors, Carrier Transport, Carrier Transport, Generation and Recombination, Recombination-Generation statistics-1, Recombination-Generation statistics-II, Recombination-Generation statistics-III.

UNIT – III
Semiconductor junctions
P-N Junction basics, P-N Junction Characteristics, P-N Junction: Effects of Bias, P-N Junction Analysis (Dark)-I P-N Junction Analysis (Dark)-II, P-N Junction Analysis (Light), P-N Junction Analysis (Light)-II, P-N Junction Analysis (Light)-III, P-N Junction Analysis (Light)-IV

UNIT – IV
First Generation Solar Cells
Generation-I Technologies (Mono Silicon Solar Cells)-II, Generation-I Technologies (Poly Silicon Solar Cells)-III, Manufacturing of Si, Generation I Technologies: GaAs Solar Cells
Second Generation Solar Cells
Generation II Technologies: CdTe Solar Cells-I, Generation II Technologies: CdTe Solar Cells-II, CdTe Solar Cells-III, Generation II Technologies: CIGS Solar Cells-IV, CIGS and Multi junction Solar Cells-V

UNIT – V
Third Generation Solar Cells
Generation III Technologies: Organic Solar Cells, Generation III Technologies: Organic and Dye Sensitized Solar Cells, Generation III Technologies: Organic Solar Cells, Generation III Technologies: Perovskite and CZTS Solar Cells

Text Books:

1. Solar Energy, S P Sukhatme, McGraw Hill Education, 4th Edition, 2017.
2. The Physics of Solar Cells, Jenny Nelson, Imperial College Press, 2003.

Reference Books:

1. Handbook of Photovoltaic Science and Engineering. Eds. A. Luque and S. Hegedus, Wiley, 2010.
2. Thin Films Solar Cells, K.L. Chopra, McGraw Hill, 2013.

3. Physics of Solar Cells: From Basic Principles to Advanced Concepts by Peter Wurfel, 2016.

Web Links:

1. https://onlinecourses.nptel.ac.in/noc25_mm27/course
2. https://archive.nptel.ac.in/courses/115/103/115103123/

Advanced Mechanics of Solids

Course Code: 2517ME17

Unit-I:

Three Dimensional Stress and Strain:

Principal stresses and Principal strains, Mohr's circle representation of tri-axial stresses and strains.

Unsymmetrical Bending:

Shear centre for sections with one axis of symmetry. Shear centre for any unsymmetrical section, stress and deflection of beams subjected to unsymmetrical bending.

Unit-II:

Bending of Plates:

Basic definitions, Stress, Curvature and Moment relations, Basic equation of plate deflection. Different boundary conditions, simply supported rectangular plates, axis symmetric loaded circular plates.

Unit-III:

Contact Stresses:

Due to two spherical surfaces in contact due two parallel cylindrical rollers in contact, Due to two curved surfaces of different radii.

Unit-IV: Buckling of Columns:

Beam columns with single concentrated load, number of concentrated loads, continuous lateral load, end couple, couples at both ends of the column, triangular loads and combined loads.

Unit-V:

Beam on Elastic Foundations:

General Theory, Infinite, Semi-infinite, and Finite beams, Classification of Beams, Beam supported by equally spaced elastic elements.

Text Books:

1. L.S. Srinath, "Advanced Mechanics of solids", 3rd Edition, TMH, 2017 ISBN: 978-1259029421.

2. J.R. Barber, "Intermediate Mechanics of materials "McGrawHill, 2001 ISBN: 978-0072325199.

Reference Books:

1. Ugural, Fenseter, "Advanced Strength and Applied Elasticity", 4th Edition, Pearson, 2003.

2. Shames, Pitarresi, "Introduction to solid mechanics", 3rd Edition, Pearson, 2015.

Weblinks:

1. https://www.brown.edu/Departments/Engineering/Courses/En1750/Notes/notes.html.
2. https://www.ktunotes.in/ktu-advanced-mechanics-of-solids-notes/.
3. https://www.csccm.in/courses/solid-mechanics-20-21.

Mechanical Vibrations and Condition Monitoring

Course Code: 2517ME18

Unit-I:
Single degree of freedom systems:
Introduction – Single degree of freedom systems. – Free and forced vibrations – Damping classification and damped systems. – Two degree of freedom systems – Free, forced, damped and undamped motions, - Use of influence coefficients, Matrix methods and Lagrange's equations, Phenomenon of beat – Dynamic absorbers. – Applications.

Unit-II:
Transient Vibrations:
Transient(Shock) vibrations as applied to single and two degree freedom systems – Use of mathematics and graphical techniques in the analysis (superposition integral, Laplace transformations, phase plane techniques).

Unit-III:
Multi degree freedom systems:
Free and forced motions in longitudinal, torsional and lateral modes, damped and undamped, critical speeds of rotors- Continuous systems – free and forced vibrations of string, bars and beams – Principle of orthogonality – Classical and energy methods by Rayleigh, Ritz and Galerkin.

Unit-IV:
Numerical methods in Vibration analysis:
Introduction, - Reduction of Vibration at the source – Control of Vibration by structural design – Material selection – Localized additions – Artificial Damping- Resilient isolation, Vibration isolation, - Vibration absorbers. Condition monitoring methods: Introduction, - design of information system – Selecting methods of monitoring – Machine condition monitoring and diagnosis.

Unit-V:
Vibration measurement and analysis:
Transducers and mounting methods, Data acquisition using instrumentation reorders / data loggers, Time domain signal analysis – Orbit analysis, Filters – Frequency domain analysis (Narrow band FFT analysis) – Nyquist criteria, Sampling, aliasing, windowing and averaging. Fault diagnosis – Interpreting vibration measurements for common machine faults – Imbalance, - Misalignment, - Bearing and Gearing Faults, Faults in induction motors – Resonances, some case studies.

Text Books:
1. SS Rao, "Mechanical vibrations", 6th Edition, Pearson, 2021. ISBN: 978-9354430363.
2. J.S. Rao, "Vibratory condition monitoring of machines", CRC press, 2000. ISBN: 978-0849309374.

Reference Books:
1. J.O. Den Hartog, "Mechanical Vibrations", McGrawHill, 1985. ISBN: 978-0070209729.

Web links:

1. https://engcourses-uofa.ca/books/vibrations-and-sound/transient-vibrations/convolution/.
2. https://snscourseware.org/snscenew/notes.php?cw=CW_5d35a09fcf3c0.

Analysis and Synthesis of Mechanisms

Course Code: 2517ME19

Unit-I:
Introduction:
Review of kinematic chains – Equivalent chains and their inversions. Position analysis: Position and systems – coordinate transformation – rotation, translation and combined motion, algebraic position analysis loop closure equations, position of any point on a linkage, transmission angles and toggle positions, position based synthesis of planar mechanisms.

Unit-II:
Kinematics of rigid bodies:
Plane motion of a rigid body, graphical velocity and acceleration analysis, instantaneous centres of velocity, centrodes, velocity of rub, analytical solutions for velocity analysis, velocity of any point on a linkage, acceleration of any point on a linkage, Coriolis acceleration, analytical solutions for velocity and acceleration analysis, case studies – Four-bar pin jointed linkage, four link slider-crank.

Unit-III:
Analytical linkage synthesis:
Types of kinematic synthesis, motion and path generation, number synthesis, dimensional synthesis, two position synthesis for rocker output, precision points, comparison of analytical and graphical two position synthesis, three position synthesis.

Unit-IV:
Graphical linkage synthesis:
Two position synthesis for rocker output, three position synthesis, position synthesis for more than three positions (four and six bar quick return), coupler curves, exact and approximate straight line mechanisms.

Unit-V:
Cam:
Terminology, types of follower, follower motions, cams, Law of cam design, single and double dwell cam design using SHM, Cycloidal displacement, Combined functions, critical path motion, practical design considerations.
Gears and Gear trains:
Law of gearing, involute tooth form, pressure angle, backlash, contact ratio, interference and method to avoid interference, gear train and its analysis.

Text Books:
1. A.K. Mallik, A. Ghosh, “Kinematics analysis and synthesis of mechanisms”, Springer-verlag, 2016. ISBN: 978-8132227437.
2. P.E. Nikravesh, “Planar multibody dynamics”, 2nd Edition, CRC press, 2018 ISBN: 978-1138744394.

Reference Books:

1. Sandor and Erdman, “Advanced mechanism design: Analysis and Synthesis”, Vol II, PHI, 2001. ISBN: 978-8120308204.
2. Shigley, Pennock and Uicker, “Theory of machines and mechanisms”, 6th Edition, Cambridge University Press, 2023. ISBN: 978-1009277150.

Web links:

1. https://api.pageplace.de/preview/DT0400.9780429611193_A38584719/preview-9780429611193_A38584719.pdf.
2. https://archive.nptel.ac.in/courses/112/106/112106270/.

Experimental Stress Analysis

Course Code: 2517ME20

Unit-I:
Introduction:
Introduction to elementary elasticity, Strain and the stress-strain relations, basic equations of strain, and plane elasticity theory.
Brittle- coating methods:
Introduction, coating stresses, brittle coating crack patterns, crack detection, ceramic- based brittle coatings, resin based brittle coatings, test procedures, calibration.

Unit-II:
Strain measurement using strain gauges:
Introduction, strain sensitivity in metallic alloys, gage construction, Strain gage adhesive and mounting methods, Gage sensitivities and gage factor, Piezoresistive properties of semiconductors, Performance characteristics of foil strain gages and semiconductor gages, Strain-Gage circuits, Analysis of Strain-Gage Data.

Unit-III:
Optical methods:
Basic optics – introduction, Optic Laws, Optical instruments – the Polariscope, the Interferome Moire Methods - Introduction, Mechanism of Formation of Moire Fringes, Different approach to Moire Fringe Analysis.

Unit-IV:
Theory of Photoelasticity:
Introduction, the Stress- Optic law, Effects of a stressed model in a plane and in a circular Polariscope, Fringel Manipulation, Isochromatic and Isoclinic Fringe Patterns, Compensation Techniques – Separation method, Calibration methods, Photoelastic materials.

Unit-V:
2-D and 3-D Photoelasticity:
Shear difference method in 3-D stress, the Scattered Light method, Frozen Stress method, Bi-Refringent coatings- Coating stresses and strains – Coating sensitivity, Coating materials, Effects of coating thickness.

Text Books:
1. Dally, J.W & Riley W.F, “Experimental Stress analysis”, 3rd Edition, McGrawHill. ISBN: 978-0070299495.
2. H. R. Lissner, C.C.Perry, “Strain Gauge Primer”, McGrawHill. ISBN: 978-0070572978.

Reference Books:
1. K. Ramesh, Developments in Photoelasticity - A renaissance. IOP Publishing, 2021. ISBN: 978-0-7503-2472-4 Advances in Vibrations and Structural Dynamics.
2. L.S. Srinath, M.R. Raghavan, K. Lingaiah, G. Gargesa, B. Pant, and K. Ramachandra, “Experimental Stress Analysis”, Tata Mc Graw Hill, 1984, ISBN: 978-0074600727.

Web links:

1. http://ndl.iitkgp.ac.in/he_document/nptel/IN__N__1_M_E__24356_E_S_A __27206_ 27207.
2. https://archive.nptel.ac.in/courses/112/106/112106068/.

Advanced Mechanical Design

Course Code: 2517ME21

Unit-I:
Material selection for design:
Engineering design process and the role of materials , Materials classification and their properties, types of material failure, Elastic and Plastic deformation, Creep deformation, Fatigue fracture under cyclic loading, Combined effects; Design and Materials selection , Iterative and stepwise nature design, Safety factors, Prototype and Component Testing, Service Experience, Examples of material selection for typical applications; Fundamentals of Plasticity – Theory of limit design, Bauschinger effect, Ludwik, Holloman equations and voce equation.

Unit-II:
Review of fundamental concepts:
Load analysis – 2D and 3D static load analysis, Case studies of static load analysis, Bicycle hand brake lever, Bicycle with pedal arm, Plier-wrench; Understanding of static failure for ductile and brittle materials; Comparison of experimental data with failure theories; significance of theories of failure; importance of factor of safety in design; Design case studies – Bracket, Bicycle hand brake lever, Bicycle with pedal arm, Plier- wrench.

Unit-III:
Fatigue failure theories:
Introduction to fatigue, Fatigue failure models, Fatigue life, Estimation of theoretical fatigue strength, Correction factors to the theoretical fatigue strength, Stress concentration, Cumulative damage and life exhaustion, Effect of mean stress on the fatigue failure, Designing for fully reversed uniaxial stresses, Designing for fluctuating uniaxial stresses, Designing for multi- axial stresses in fatigue.

Unit-IV:
Introduction to fracture and creep:
Fundamentals of Fracture mechanics, Mechanism of fracture – Cleavage fracture, Ductile fracture and inter-granular fracture, Griffiths theory, Orowan theory, Theoretical fracture strength, Irwin's fracture analysis, Design case studies – Bicycle with pedal arm, Plier- wrench. Fundamentals of degradation, Creep mechanisms, Temperature dependence of creep, Correlations to determine rupture time under creep condition, Larson- Miller, Manson and Haferd, Orr-Sherby-Dorn.

Unit-V:
Design for failure prevention:
Surface Geometry, Mating surfaces, Friction, Surface failures , Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue wear, Static and Dynamic Contact stresses – Spherical contact, Cylindrical contact and General contact, Design case studies – Ball bearing, Cylindrical roller bearing, Cam-follower contact.

Textbooks:

1. R.L. Norton, “Machine design- an integrated approach”, Pearson Education, 5th Edition, 2018. ISBN: 978-0134319656
2. R.G. Budynas, J.K. Nisbett, “Shigley’s Mechanical Engineering Design”,Mc Graw Hill Publication, 11th Edition, 2020. ISBN: 978-1260113307.

Reference Books:

1. Prashant Kumar, “Elements of Fracture Mechanics”, McGraw Hill Publication, 2017, ISBN: 978-0070669898
2. M. Meyers and K. Chawla, “Mechanical Behaviour of materials”, Cambridge University Press, 2nd Edition, 2009, ISBN: 978-0521870376.

Web links:

1. https://ocw.mit.edu/courses/2-002-mechanics-and-materials-ii-spring-2004/pages/lecture-notes/.
2. https://enterfea.com/2d-vs-3d-finite-element-analysis/.
3. http://ndl.iitkgp.ac.in/he_document/nptel/nptel/112106293_1djfbs9eraiodq_e7jm7t2ltmv_n0pupz.
4. https://becht.com/training/course-content-pressure-equipment-engineering-fundamentals/

Advanced Machining and Micromachining Processes

Course Code: 2517ME22

Unit-I:
Introduction:
Trends in modern manufacturing; characteristics and classification of modern manufacturing methods, considerations in the process selection. Mechanical Processes: Ultrasonic Machining (USM), Abrasive Jet Machining (AJM), Water Jet Machining (WJM) and Abrasive Water Jet Machining (AWJM) processes. Electrochemical & Chemical Processes: Electrochemical Machining (ECM), Electrochemical Grinding (ECG), Electrochemical deburring, Electrochemical honing and Chemical Machining (CM) processes.

Unit-II:
Thermal Processes:
Electrical Discharge Machining (EDM), Wire cut electro discharge machining, Laser Beam Machining (LBM), Electron Beam Machining (EBM), Plasma Arc Machining (PAM) and Ion Beam Machining (IBM), Hybrid Machining Processes: Electrochemical discharge machining (ECDM), Thermally assisted machining (TAM), Vibration-assisted milling, Laser-assisted machining (LAM), Abrasive flow machining (AFM), Magnetic abrasive flow machining (MAFM).

Unit-III:
Introduction:
Introduction & Classification of Micromachining Processes, Traditional Mechanical Micromachining Processes: Micro Turning, Micro Milling, Micro Drilling, Mechanical type Advanced Micromachining Processes: Abrasive Jet Micromachining (AJM), Ultrasonic Micromachining (USM), Abrasive Water Jet Micromachining (AWJM), Chemical and Electrochemical type Advanced Micromachining Processes: Electrochemical Micromachining (EMM), Electrochemical Micro Deburring, Chemical and Photochemical Micromachining.

Unit-IV:
Thermoelectric type Micromachining Processes:
Electric Discharge Micromachining (EDM), Wire cut electro discharge machining (WIRE EDM), Electrical discharge diamond grinding, Electrolytic In-Process Dressing (ELID), Laser Beam Micromachining (LBM), Electron Beam Micromachining (EBM), Plasma arc micromachining, Electron bean micromachining, Ion beam micromachining.

Unit-V:
Hybrid micromachining processes:
Vibration assisted micromachining, Thermal assisted micromachining, Pulse assisted micromachining, Magnetic assisted micromachining, Vibration assisted micromachining, Abrasive based Nano Finishing Processes: Abrasive Flow Finishing (AFF), Chemo mechanical Polishing (CMP), Magnetic Abrasive Finishing (MAF), Magnetorheological Finishing (MRF), Magnetorheological Abrasive Flow Finishing (MRAFF), Magnetic Float Polishing (MFP).

Text Books:

1. P. C. Pandey and H. S. Shan, Modern Machining Processes, Tata McGraw Hill, New Delhi, 1st Edition, 2003, ISBN: 9780070965539.
2. V. K. Jain, Introduction to Micromachining, Narosa publishing house, New Delhi, 2nd Edition, 2019, ISBN: 978-81-8487-361-0.

Reference Books:

1. V. K. Jain, Advanced Machining Processes, Allied publishers, New Delhi, 1st Edition, 2008, ISBN : 978-8177642940.
2. G. Benedict, Nontraditional Manufacturing Processes, Marcel Dekker, New York, 1st Edition, 1987, ISBN 978-0824773526: .
3. S. Kunar, G. Kibria, P. Chatterjee, Electro-Micromachining and Microfabrication: Principles and Research Advances, CRC Press, 1st Edition, 2024, ISBN: 9781774913796.

Web links:

1. https://www.3erp.com/blog/micro-machining/.
2. https://unacademy.com/content/gate/study-material/mechanical-ngineering/principles-of non-traditional-machining-process/.
3. https://ocw.mit.edu/.

Advanced Manufacturing Process

Course Code: 2517ME23

Unit I:
Introduction:
General survey and classification of welding processes, Use of conventional fusion welding processes, General characteristics of an arc, ionisation, dissociation, arc column, anode and cathode fall zones, Electrical conductivity of the arc, heat transfer inside the arc and arc ignition.

Unit II:
Welding:
Principles of Gas Tungsten Arc (GTA) welding, plasma arc welding, advances in GTA welding Gas metal arc, shielded metal arc, flux cored arc, submerged arc welding -consideration of shielding gases, electrode polarity, current setting, types of metal transfer , process efficiency, melting rate, spatter losses and influence of external magnetic field on arc stability and advanced GMAW processes. Electrode coverings and their functions, types of fluxes.

Unit III:
Electron beam welding:
Introduction to power beam welding processes laser and electron beam welding processes - principles and modes of operation, applications and advantages.

Unit IV:
Processes:
Process principles and overview on types of processes (spot, projection, butt, seam, and flash) Joule effect and temperature distribution.

Unit V:
Types of Welding:
Modern welding processes – friction welding, Micro welding process, adhesive bonding, exothermic (thermite) welding.

Text Books:

1. R. S. Parmar, “Welding process and Technology”, Khanna Publishers, ISBN-13: 978-8174092304.
2. MD. Ibrahim Khan, Welding Science and Technology, New Age International Publishers, ISBN-13: 978-8122424540.
3. S. V. Natkarni, “Advanced Welding Technology”, Oxford IBH Publishers, ISBN-13: 978-8120412150.

Reference Books:

1. Cary, Howard, “Modern Welding Technology”, prentice Hall, ISBN-13: 978-0131130298.
2. Christopher Davis, “Laser Welding - A Practical Guide”, Jaico Publishing House, ISBN-13: 978-8184953242.
3. Sindo Kou, “Welding Metallurgy” Wiley–Blackwell, ISBN-13: 978-1118353636.

Web Links:

1. https://archive.nptel.ac.in/courses/112/103/112103263/
2. https://archive.nptel.ac.in/courses/113/106/113106087/
3. https://archive.nptel.ac.in/courses/112/103/112103244/

Automation in Manufacturing

Course Code: 2517ME24

Unit 1:
Introduction:
Importance of automation in the manufacturing industry. Use of mechatronics. Systems required. Design of an automated system: Building blocks of an automated system, working principle and examples.

Unit 2:
Fabrication:
Fabrication or selection of various components of an automated system. Specifications of various elements. Use of design data books and catalogues.

Unit 3:
Sensors:
study of various sensors required in a typical automated system for manufacturing. Construction and principle of operation of sensors. Microprocessor Technology: signal conditioning and data acquisition, use of microprocessor or micro controllers. Configurations. Working.

Unit 4:
Drives:
electrical drives – types, selection criteria, construction and operating principle. Mechanisms: Ball screws, linear motion bearings, cams, systems controlled by camshafts. Mechanisms: Electronic cams, indexing mechanisms, tool magazines, and transfer systems.

Unit 5:
Hydraulic systems:
hydraulic power pack, pumps, valves. Hydraulic systems: designing of hydraulic circuits. Pneumatic systems: configurations, compressors, valves, distribution and conditioning. CNC technology: basic elements, interpolators and programming.

Text Books

1. Boltan, W., Mechatronics: electronic control systems in mechanical and electrical engineering, Longman, Singapore, 1999.
2. Regtien, P. P. L., Sensors for mechatronics, Elsevier, USA, 2012.
3. Rao, P. N., CAD/CAM Principles and Applications, Tata McGraw Hill, New Delhi, 2010

Reference Books

1. Gaonkar, R. S., Microprocessor architecture, programming and applications with the 8085, Penram International Publishing (India), Delhi, 2000, ISBN-13: 978-8185780456.
2. Bradley, D. A., Dawson D., Burd, N. C. and Loader A. J. Mechatronics: Electronics in products and processes, CRC Press, Florida, USA, 2010, ISBN-13: 978-1439814058.
3. Norton, R. L., Cam Design and Manufacturing Handbook, Industrial press Inc, 2002, ISBN-13: 978-0831130915.
4. Groover, M. P., Automation, Production Systems, and Computer-Integrated Manufacturing, Prentice Hall, 2001, ISBN-13: 978-0130348171.

Web Links:

1. https://onlinecourses.nptel.ac.in/noc22_me123/preview.
2. https://onlinecourses.nptel.ac.in/noc22_me50/preview.

Control of Robotic System

Course Code: 2517ME25

UNIT – I:
Introduction:
MATLAB for Control system Basics, Language Fundamentals, Mathematical Operations, Graphics, Programming.

UNIT – II:
Basics of Control, Control Systems:
Types of Controllers, Introduction to closed loop control, Differential Equation, Transfer function, Block diagram, Signal Flow Graph.

UNIT – III:
Time Response and Frequency Response:
Time Response, Routh-Hurwitz test, relative stability, Root locus design, construction of root loci, phase lead and phase-lag design, lag-lead design, Frequency response, Bode, polar, Nyquist plot.

UNIT – IV:
Linear Control System:
Concept of states, state space model, different form, controllability, observability; pole placement by state feedback, observer design, P, PI & PID Controller, control law partitioning, modelling and control of a single joint.

UNIT – V:
Non-Linear Control System:
Common physical non-linear system, phase plane method, system analysis by phase plane method, stability of non-linear system, Lyapunov's stability criterion, the control problems for manipulators.

Text Books:
1. Control Systems, M. Gopal, McGraw-Hill, 4th Edition, 2012, ISBN-13: 978-0071333276.
2. Modern Control Engineering, K. Ogata, Prentice Hall India, 5th Edition, 2015, ISBN-13: 978-8120339549.
3. Robot Modeling and Control, M. Spong, M. Vidyasagar, S. Hutchinson, Wiley & Sons, 1st Edition, ISBN-13: 978-0471649908.

Reference Books:
1. Introduction to Robotics: Mechanics and Control, J. J. Craig, Addison-Wesley, 3rd Edition, ISBN-13: 978-0201543612.
2. Linear Systems: Optimal and Robust Control, Alok Sinha, Taylor & Francis, ISBN-13: 978-1466502973.

Web Links:
1. https://matlabacademy.mathworks.com/details/matlab-onramp/gettingstarted
2. https://onlinecourses.nptel.ac.in/noc20_ge05/preview
3. https://onlinecourses.nptel.ac.in/noc22_de09/preview

Leading Edge Additive Engineering

Course Code: 2517ME26

Unit I:
Overview of Rapid Product Development:
Product Development Cycle, virtual prototyping, physical prototyping.

Unit II:
Solid Modelling:
Data formats, conversion, checking, repairing and transmission. Synergic integration technologies, Part slicing and Build Orientation, Area-filling strategies, applications and limitations of RPM.

Unit III:
Classification of RPM processes:
Sheet lamination, Material extrusion, Photo-polymerization.

Unit IV:
Powder Bed Fusion:
Binder Jetting, Direct Energy Deposition. Popular RPM processes.

Unit V:
Rapid prototyping:
Selection of rapid prototyping, tooling and manufacturing systems based on product requirements.

Text Books:
1. Ian Gibson, David Rosen, and Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing" Springer, New York, NY, 2015.
2. Frank W. Liou, Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development, CRC Press, Taylor and Francis Group, 2007.

Reference Books:
1. D. Pham, S.S. Dimov, "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling", Springer-Verlag London, 2001.
2. K. Zhou, M. Habibnejad-Korayem, J. W. K. Kwan, Additive Manufacturing: Materials, Processes, Quantifications, and Applications, Butterworth-Heinemann, 1st Edition (2021), ISBN-13: 978-0128198406.

Web Links:
1. https://archive.nptel.ac.in/courses/112/103/112103306/.
2. https://onlinecourses.nptel.ac.in/noc24_me130/preview.

Fracture Mechanics

Course Code: 2517ME27

Unit-I:
Introduction:
Brittle and Ductile Fracture, Modes of Fracture Failure, Surface Energy, Griffith's Dilemma, Realization and Analysis, Energy Release Rate, Energy Release Rate of DCB Specimen, An elastic Deformation at Crack-tip, Crack Resistance, Stable and Unstable Crack Growth, Critical Energy Release Rate.

Unit-II:
Stress Intensity Factor:
Linear Elastic Fracture Mechanics(LEFM), Westergaard's Approach, Applications of Westergaard Approach, Crack in a plate of finite dimensions, Edge cracks, Embedded Cracks, The relation between Gi and Ki, Critical Stress Intensity Factor, Bending and Twisting of Cracked Plates, Approximate Shape and Size of the Plastic Zone, Effective Crack length, Effect of Plate thickness.

Unit-III:
J-Integral:
Definition of the J-Integral, Path independence, Stress- Strain Relation, Experiments to determine the critical J-integral, Comments on the Numerical Evaluation of J-Integral, A Simplified relation for the J-integral, Applications to Engineering problems, Crack tip opening displacement, Relationship between CTOD, Kr and Gr for small scale yielding, Equivalence between CTOD and J.

Unit-IV:
Test Methods:
KiC-Test technique, Test methods to determine JiC, Test methods to determine GiC and GiiC, Determination of critical CTOD. Fracture parameters: Direct methods to determine fracture parameters, Indirect methods to determine fracture parameters, Mixed mode crack initiation and growth.

Unit-V:
Crack detection through non-destructive testing:
Examination through Human senses, Liquid penetration inspection, Ultrasonic testing, Radiographic imaging, Magnetic Particle Inspection.

Text Books:
1. Prashant Kumar, "Elements of Fracture Mechanics", McGraw Hill Publication, 2017, ISBN: 978-0070669898.
2. T.L .Anderson, "Fracture mechanics: fundamentals and applications", 4th Edition, CRC Press, 2017 ISBN: 978-1498728708.

Reference Books:

1. S. T. Rolfe, J. M. Barsom, “Fracture and Fatigue control in structures”, PHI, 1987, ISBN: 978-0139221776.
2. D. Broek, “Elementary Engineering fracture mechanics”, Springer Science & Business Media, 4th Edition, 2012. ISBN: 978-9400722102.

Web links:

1. https://www.chemeurope.com/en/encyclopedia/Fracture_mechanics.html.
2. https://ocw.mit.edu/courses/3-35-fracture-and-fatigue-fall-2003/.
3. http://www.ltas-cm3.ulg.ac.be/FractureMechanics/.

Failure Analysis and Design

Course Code: 2517ME28

Unit-I:
Introduction:
The role of failure prevention analysis in Mechanical Design, Material failure modes and their identification.

Unit-II:
Combined Stresses, theories of failure and their use in Design:
Stage of stress and relation between stress and strain. Static loading, Fatigue loading.
High cycle fatigue:
Fatigue testing, S-N-P curves, endurance diagrams, influence factors, stress concentration factors and notch sensitivity, fatigue design for combined stress, cumulative damage and life prediction.

Unit-III:
Fatigue testing procedures and statistical interpretation of data:
Loading regimes for testing and statistical interpretation, low cycle fatigue, fretting. Fracture mechanics principles in design practice, contact fatigue, high temperatures, corrosion, Shock and impact loading.

Unit-IV:
Failure analysis techniques and preventive measures:
Non-destructive testing techniques and metallographic techniques.

Unit-V:
Component failures:
Bearings, Gears, Chain and Belt Drives, Lifting equipment, Welded constructions and Screw fastenings, Pressure vessel, Seals, Shafts and Springs.

Textbooks:
1. J.A. Collins, “Failure of materials in mechanical design: Analysis, prediction and prevention”, 2nd Edition, John Wiley & sons, 2012. ISBN: 978-1119992317.
2. N.E. Dowling, “Mechanical behaviour of materials”, 4th Edition, Pearson, 2017. ISBN: 978-0134382597.

Reference Books:
1. S. Suresh, “Fatigue of materials”, 2nd Edition, Cambridge University Press, 2015. ISBN: 978-1107693794.
2. R.J. Shigley and W.T. Becker, “Failure analysis and prevention”, ASM Handbook, Vol 11. ISBN: 978-0871705794.

Web links:
1. https://tractian.com/en/blog/mechanical-failures-prevention.
2. https://fatigue-life.com/high-cycle-fatigue/.
3. https://www.linkedin.com/advice/0/what-best-practices-fatigue-testing-data-analysis.

Artificial Intelligence and Machine Learning for Mechanical Systems

Course Code: 2517ME29

Unit-I:
Introduction to Mechanical systems:
Evolution in the context of Industry 4.0, Key issues: Adaptability, Intelligence, Autonomy, Safety, Sustainability, Interoperability, Flexibility of Mechanical systems.

Unit-II:
Introduction of Statistics:
Descriptive statistics: Central tendency measures, Dispersion measures, data distributions, Centre limit theorem, Sampling, sampling methods. Inferential statistics: Hypothesis testing, confidence level, degree of freedom, p-value, Chi-square test, ANOVA, Correlation V's Regression, Uses of Correlation and Regression.

Unit-III:
Artificial Intelligence:
Brief overview of AI history, Problem formulation, Graph structure, Graph implementation, state space representation, search graph and search tree, search algorithms: random search, depth-first, breadth-first search and Uniform-cost search,
Heuristic: best first search, A* and AO* algorithm, generalization of search problems, Ontology, Fuzzy -Meta heuristics.

Unit-IV:
Machine Learning:
Overview of supervised and unsupervised learning, Supervised learning: Linear Regression, Non-linear Regression model evaluation methods, Logistic Regression, Neural Networks. Un-supervised learning: K-means clustering, C-means Clustering, Convolutional Neural Networks (CNN), Pooling, Padding Operations, Interpretability in CNNs, Limitations in CNN. Cases with respect to different mechanical systems.

Unit-V:
Introduction to Raspberry Pi:
Installation of Raspbian OS on Raspberry Pi, Controlling LED using Raspberry Pi, Integrating IR Sensor with Raspberry Pi, Controlling LED with IR Sensor, Integrating Temperature and amp, Humidity sensor with Raspberry Pi read current environment values, Collecting the sensor data using Raspberry Pi, Matlab toolboxes, Simulink, Mechanical systems implementation, From features to software components, Mapping software components to ECUs.

Textbooks:

1. Rajkumar, D.D.Niz and M.Klein, "Cyber-Physical Systems", Pearson Education, 2017 ISBN: 978-0134099601.
2. Rajeev Alur, "Principles of Cyber-Physical Systems", MIT Press, 2023, ISBN: 978-0262047831.

Reference Books:

1. R. Levine et al., "A Comprehensive guide to AI and Expert systems", McGraw Hill Inc, 1986 ISBN: 978-0070152818.
2. E.A. Lee and S.A.Seshia, "Introduction to Embedded systems: A cyber-physical systems approach", 2nd Edition, MIT Press, 2011, ISBN-10: 0262533812, ISBN-13: 978-0262533812.
3. C.Cassandras, S.Lafortune, "Introduction to Discrete Event Systems", 3rd Edition, Springer, 2021, ISBN: 978-3030504050.
4. Montgomery Douglas, "Design and Analysis of experiments", 10th Edition, John Wiley and Sons, 2019. ISBN: 978-1119675572.

Web links:

1. https://www.intechopen.com/chapters/80058.
2. https://www.geeksforgeeks.org/architecture-of-raspberry-pi/
3. https://www.cuemath.com/data/descriptive-and-inferential-statistics/.
4. https://www.javatpoint.com/machine-learning.

Advanced FEM and Simulation Techniques

Course Code: 2517ME30

Unit I:
Finite element modelling coordinates and shape functions:
Assembly of Global stiffness matrix and load vector. Finite element equations, Treatment of boundary conditions, Quadratic shape functions. Analysis of Trusses: Introduction, analysis of plane trusses, local and global stiffness matrix, treatment of boundary conditions, solutions, temperature effects. Analysis of Beams: Formulation, load vector, boundary conditions, shear force and bending moment, solutions.

Unit II:
Higher order and Isoparametric elements:
One dimensional quadratic and cubic elements in natural coordinates, two dimensional four noded isoparametric elements and numerical integration. **Steady State Heat Transfer Analysis:** One dimensional analysis of conduction, convection problems.

Unit III:
Finite element analysis of 1-D problems:
formulation by different approaches (direct, potential energy and Galerkin), Derivation of elemental equations and their assembly. Applications in heat transfer, fluid mechanics and solid mechanics. Bending of beams, analysis of truss and frame.

Unit IV:
Finite element analysis of 2-D problems:
finite element modelling of single variable problems, triangular and rectangular elements, Applications in heat transfer, fluid mechanics.

Unit V:
2D problem for Plane stress and plane strain problems:
Bending of plates, Eigen value and time dependent problems, Discussion about pre-processors, postprocessors and finite element package ANSYS.

Text Books:
1. Introduction to Finite Elements in Engineering, T.R. Chandrupatla and A.D. Belegundu, PHI publications, 4th Edition, 2011, ISBN-13: 978-0132162746.
2. A First Course in the Finite Element Method, Daryl L. Logan, Cengage Learning India Private Limited, 6th edition, 2017, ISBN-13: 978-8131523537.

Reference Books:
1. An Introduction to the Finite Element Method, J.N. Reddy, McGraw Hill Education, 4th Edition, 2020, ISBN-13: 978-1259861901.
2. Concepts and Applications of Finite Element Analysis, Cook et al, Wiley Publications, 4th edition, 2007, ISBN-13: 978-0471356059.

Web Links:
1. https://nptel.ac.in/courses/112/104/112104193/
2. https://nptel.ac.in/courses/112/104/112104205/

Data Analytics

Course Code: 2517ME31

Unit I:
Introduction:
Sources, modes of availability, inaccuracies, and uses of data. Data Objects and Attributes: Descriptive Statistics; Visualization; and Data Similarity and Dissimilarity.

Unit II:
Pre-processing of Data:
Cleaning for Missing and Noisy Data; Data Reduction – Discrete Wavelet Transform, Principal Component Analysis, Partial Least Square Method, Attribute Subset Selection; and Data Transformation and Discretization. Inferential Statistics: Probability Density Functions.

Unit III:
Inferential Statistics through Hypothesis Tests Business Analytics:
Predictive Analysis (Regression and Correlation, Logistic Regression, In Sample and Out-of-Sample Predictions), Prescriptive Analytics (Optimization and Simulation with Multiple Objectives); Mining Frequent Patterns: Concepts of Support and Confidence; Frequent Itemset Mining Methods; Pattern Evaluation.

Unit IV:
Classification:
Decision Trees – Attribute Selection Measures and Tree Pruning; Bayesian and Rule-based Classification; Model Evaluation and Selection; Cross-Validation; Classification Accuracy; Bayesian Belief Networks; Classification by Backpropagation; and Support Vector Machine. Clustering: Partitioning Methods – k-means Hierarchical Methods and Hierarchical Clustering Using Feature Trees; Probabilistic Hierarchical Clustering; Introduction to Density-, Grid-, and Fuzzy and Probabilistic Model-based Clustering Methods; and Evaluation of Clustering Methods.

Unit V:
Machine Learning:
Introduction and Concepts, Ridge Regression, Lasso Regression, and k-Nearest Neighbours, Regression and Classification. Supervised Learning with Regression and Classification Techniques, Bias-Variance Dichotomy, Linear and Quadratic Discriminant Analysis, Classification and Regression Trees, Ensemble Methods: Random Forest, Neural Networks, Deep Learning.

Textbooks:

1. Applied Machine Learning,1e, M.Gopal, Mc Graw Hill Education, 2018, ISBN-13: 978-9353162344.
2. Data Mining and Analysis: Fundamental Concepts and Algorithms, Mohammed J. Zaki, Wagner Meira Jr. Publisher: Cambridge University Press ISBN: 978-1107096025
3. Introduction to Data Mining with Case Studies, G.K. Gupta, Publisher: PHI Learning Pvt. Ltd. ISBN: 978-8120347452.

Reference Books

1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012, ISBN-13: 978-0262018029.
2. Soman K.P., Shyam Diwakar, Ajay V, Principles of Data Mining, PHI Learning Pvt. Ltd, ISBN: 978-8120328970.
3. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007, ISBN: 978-0387310732.

Web Links:

1. https://www.coursera.org/learn/machine-learning.
2. https://classroom.udacity.com/courses/ud120.
3. http://videolectures.net/Top/Computer_Science/Machine_Learning/.
4. https://onlinecourses.nptel.ac.in/noc18_cs26.

Quality and Reliability Engineering

Course Code: 2517ME32

UNIT I:
Introduction and Statistical Process Control:
Introduction: -definitions of quality, Evolution of Quality: Inspection, Quality Control, Quality assurance Customer-Orientation: Internal & External Customer Concept, Life cycle approach to quality costs- Prevention; Appraisal and Failure costs. Seven SPC tools -Histogram, Check sheets, Ishikawa diagrams, Pareto, Scatter diagrams, Control charts and flow charts.

UNIT II:
Online Quality Control:
Control chart for attributes –control chart for non-conforming– p chart and np chart – control chart for nonconformities– C and U charts, Control chart for variables – X chart, R chart and σ chart -State of control and process out of control identification in charts, pattern study and process capability studies.

UNIT III:
Offline Quality Control:
Lot by lot sampling – types – probability of acceptance in single, double, multiple sampling techniques – O.C. curves – producers Risk and consumers Risk. AQL, LTPD, AOQL concepts standard sampling plans for AQL and LTPD- uses of standard sampling plans.

UNIT IV:
Reliability Concepts:
Reliability engineering - fundamentals – failure data analysis, Mean failure rate, Mortality curves concept of burn –in period, useful life and wear out phase of a system, mean time to failure, meantime between failure, hazard rate – failure density and conditional reliability-Maintainability and availability – simple problems.

UNIT V:
Reliablity Estimation:
System reliability: Series, Parallel and Mixed configurations, Reliability improvement techniques, use of Pareto analysis – design for reliability – redundancy unit and standby redundancy- fault tree analysis – Optimization in reliability – Product design – Product analysis – Product development – Product life cycles.

Text Books:

1. Douglas. C. Montgomery, Introduction to Statistical quality control, 7th edition, John Wiley, 2012.
2. Srinath. L.S., "Reliability Engineering", 4th edition Affiliated East west press, 2011.

Reference Books:

1. Besterfield D.H., Quality Control, 8th edition, Prentice Hall, 2009.
2. Connor, P.D.T.O., "Practical Reliability Engineering", 5th edition, Wiley India, 2012.
3. Grant, Eugene .L Statistical Quality Control, TMH, 2005.
4. John. S. Oakland. Statistical process control, Elsevier Butterworth-Heinemann, 2008.
5. Monohar Mahajan, Statistical Quality Control, Dhanpat Rai & Sons 2016.

Web Links:

1. https://www.youtube.com/watch?v=zJS4o2lkGak.
2. https://www.youtube.com/watch?v=0g6BXhWAYBI.
3. https://www.youtube.com/watch?v=9q_-D40FI1Q.
4. https://www.youtube.com/watch?v=ouMnoLcK6uw.

Process Modelling and Optimization

Course Code: 2517ME33

Unit I:
Introduction to Processes and Variation, Probability Models of Manufacturing Processes.

Unit II:
Statistical modelling and control in manufacturing processes, Sampling Distributions.

Unit III:
Statistical Hypotheses, Statistical Process Control.

Unit IV:
Design of Experiments, ANOVA. Use of experimental design and response surface modelling to understand manufacturing processes.

Unit V:
Multi criteria optimization. Case studies.

Text Books:

1. R. Venkata Rao, "Advanced Modeling and Optimization of Manufacturing Processes", Springer, 2011, ISBN-13: 978-0857290151.
2. Nirmal K. Sinha, "Experiments: Planning, Analysis, and Optimization", Wiley, 2016, ISBN-13: 978-1118489724.
3. S. K. Gupta, "Statistical Quality Control", 10th Edition, S. Chand Publication, ISBN-13: 978-8121903310.

Reference Books:

1. Douglas C. Montgomery, Design and Analysis of Experiments, Wiley, 2019, ISBN-13: 978-1119492440.
2. Douglas C. Montgomery, Statistical Quality Control, Wiley, 2020, ISBN-13: 978-1119390234.
3. Jingsheng Lou, Yibo Lin, Xiaoqing Xu, Multi-Objective Optimization in Physical Synthesis of Integrated Circuits, Springer, 2018, ISBN-13: 978-3319999987.

Web Links:

1. https://onlinecourses.nptel.ac.in/noc23_me109/preview.
2. https://nptel.ac.in/courses/111105039.

Robotic Mobility Systems

Course Code: 2517ME34

UNIT – I:
Introduction:
Position and orientation of objects, objects coordinate frame Rotation matrix, Euler angles Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effector, Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates.

UNIT – II:
Direct Kinematics:
Link coordinates D-H Representation, The ARM equation. Direct kinematic analysis for Four axis, SCARA Robot and three, five and six axis Articulated Robots.

UNIT – III:
Inverse Kinematics:
The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and three and five axis, Articulated robot.

UNIT – IV:
Workspace Analysis and Trajectory Planning:
Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, Joint space technique - continuous path motion, Interpolated motion, straight line motion and Cartesian space technique in trajectory planning.

UNIT – V:
Manipulator Dynamics:
Introduction, Lagrange's equation kinetic and potential energy. Link inertia Tensor, link Jacobian Manipulator inertia tensor. Gravity, Generalized forces, Lagrange-Euler Dynamic model, Dynamic model of a two-axis planar robot, Newton Euler formulation, Lagrange - Euler formulation, problems.

Text Books:

1. Richard D. Klafter, A. Thomas, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, PHI Learning. 2009, ISBN-13: 978-8120310470.
2. Francis N. Nagy Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc. ISBN-13: 978-0132796668.

Reference Books:

1. Bernard Hodges, Industrial Robotics, 2nd Edition, Jaico Publishing house, ISBN-13: 978-8184953006.
2. John J. Craig, Introduction to Robotics Mechanics and Control, 3rd Edition, Pearson, ISBN-13: 978-0132025074.

Web Links:

1. https://www.ros.org/.
2. https://www.classcentral.com/course/robotics-delft-university-of-technology-hello-rea-11555.
3. https://www.classcentral.com/course/udemy-ros-essentials-68029.

Advanced Composite Materials

Course Code: 2517ME35

UNIT-I:
Introduction:
Introduction to Composites, function of the matrix and reinforcement in composites. Classification: polymer matrix composites, metal matrix composites, ceramic matrix composites, carbon- carbon composites, fiber reinforced composites, particulate reinforced composites and nature-made composites.
Reinforcement types: Fiber Glass, Silica, Kevlar, carbon, boron, silicon carbide, and boron carbide.

UNIT-II:
Manufacturing Methods:
Polymer Matrix Composites- Thermoset Composite manufacturing- Lay- up processes, Spray up process, Fiber placement process, Resin transfer moulding, Vaccum assisted resin transfer moulding, Compression moulding process, Filament winding. Thermoplastic Composite manufacturing- Sheet moulding, Injection moulding, sheet moulding, Calendaring, Extrusion, Blow moulding, rotational moulding, Thermoforming.
Metal Matrix Composites- Solid state methods- hot isostatic pressing (HIP), Foil diffusion bonding. Liquid state methods- Stir casting, Squeeze casting, Pressure infiltration; Ceramic matrix composites- sintering, CVD.

UNIT-III:
Composites Design and Test:
Laminate theory, Rule of mixtures, symmetry and balance. Non- destructive testing of Composites- Visual inspection, Tap testing, Ultrasonic inspection, X-ray inspection, Thermography. Manufacturing process selection: Cost, performance, size shape, rate of production. Steps for process selection.

UNIT-IV:
Multi-Functional Composites:
Properties of multi-functional composites, Fabrication techniques of multi-scale Composites. Methods of CNT Incorporation within Multi-scale Composites-Dispersion, Ultrasonication. Growth of CNTs on Fibre Surface- Spraying Method, Transfer Printing, Chemical Grafting Process. Properties of Multi-scale Composites- Mechanical properties, Electrical and Thermal Conductivity, Electromagnetic Shielding, Self-sensing Properties.

UNIT-V:
Polymer Composite Materials:
Synthesis of Graphene- Bottom-up approaches, Top-down approaches. Surface modification of grapheme - Non-covalent modification, Covalent modification. Fabrication of grapheme polymer composites- Solution mixing, In-situ polymerization, Melt blending, other methods. Applications- Structural reinforcement materials, Functional materials, Biomedical applications.

Text Books:

1. Material Science and Technology –Composites by R.W. Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

Reference Books:

1. Composite Materials – K.K. Chawla.
2. Composite Materials Science and Applications – Deborah D.L. Chung.
3. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W

Web Links:

1. http://nptel.ac.in/courses/103107125/.
2. http://nptel.ac.in/courses/103107125/14.
3. https://link.springer.com/content/pdf/bfm%3A978-3-642-54634-1%2F1.pdf.

Material Characterization

Course Code: 2517ME36

Unit-I:
X-RD Techniques:
Single crystal orientation, Texture studies, Lattice parameter.

Unit-II:
Chemical Analysis:
Stress analysis. TEM: Theories of contrast in crystal, electron diffraction, SAD patterns, lattice defects, precipitates, second phases, specimen preparations.

Unit-III:
SEM:
Electron - specimen interactions; modes of working, X-ray, auger induced conductivity, high resolution scanning transmission microscopy, Field ion and field emission microscope.

Unit-IV:
Thermal Analysis:
Thermo gravimetric analysis, Differential thermal analysis, Differential Scanning calorimetry, Thermo mechanical analysis and dilatometry.

Unit-V:
Surface Analysis: Atomic force microscopy, scanning tunneling microscopy, X-ray photoelectron spectroscopy.

Text Books:

1. B. D. Cullity and S. R. Stock, Elements of X-ray Diffraction, 3rd edition, Upper Saddle River, NJ, USA: Prentice Hall, 2001.
2. S. Zhang, L. Li, and A. Kumar, Introduction to the Characterization of Materials. Boca Raton, FL, USA: CRC Press, 2008.
3. Y. Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, 2nd edition Singapore: Wiley, 2013.

References Books:

1. P. G. Grundy and G. A. Jones, Electron Microscopy in Study of Materials, Edward Ernold, 1976.
2. B. D. Cullity, Elements of X-ray Diffraction, Addison - Wesley Publications, 1978.
3. P. E. J. Flewitt & R. K. Wild, Physical Methods of Materials Characterization, IOP, 1994 Publishing Ltd.
4. Metals Hand Book, 10, ASM, Metals Park, Ohio, 1986.

Web Links:
1. https://nptel.ac.in/courses/113106034
2. https://online.vtu.ac.in/course-details/Material-Characterization
3. https://onlinecourses.nptel.ac.in/noc24_mm41/preview.

Surface Engineering

Course Code: 2517ME37

Unit-I:
Surface Cleaning:
Classification and Selection of Cleaning Processes Finishing Methods: Classification and Selection of Finishing Processes; Topography of Surfaces; Microstructural characteristics. Surfaces Plating and Electroplating: Electrodeposition Processes: Copper Plating; Nickel Plating; Zinc Plating; Zinc Alloy Plating; Selective (Brush) Plating, Electroforming.

Unit-II:
Non-electrolytic Deposition Processes:
Eletroless Nickel Plating; Electroless Alloy Deposition Dip, Barrier and Chemical Conversion Coatings: Batch Hot Dip Galvanized Coatings; Phosphate Coatings; Chromate Conversion Coatings; Rust Preventive Compounds; Painting.

Unit-III:
Ceramic Coatings and Linings:
Anodizing. Vacuum and Controlled – Atmosphere Coating and Surface Modification Processes: Thermal Spray Coatings, Chemical Vapor Deposition of Non -semiconductor Materials.

Unit-IV:
Chemical Vapor Deposition of Semiconductor Materials:
Plasma - Enhanced Chemical Vapor Deposition; Growth and Growth - related Properties of Films Formed by Physical Vapor Deposition, Vacuum Deposition, Reactive Evaporation and Gas Evaporation, Sputter Deposition; Ion Plating; Ion-Beam-Assisted Deposition; Arc Deposition; Ion Implantation.

Unit-V:
Diffusion Coatings:
Pulsed - Laser Deposition. Testing and Characterization of Coatings and Thin Films: Film Thickness Measurements Using Optical Techniques; Corrosion Testing; Evaluation of Mechanical Properties of Thin Films.

Text Books:

1. Matthews and E. D. Mc Cafferty, Surface Engineering for Corrosion and Wear Resistance, 1st ed. Boca Raton, FL, USA: CRC Press, 1995.
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1. P. K. Dutta & I. S. Gray, Surface Engineering, Vol. I - III, Royal Society of Chemistry, 1993.
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1. https://archive.nptel.ac.in/courses/112/107/112107248/.
2. https://onlinecourses.nptel.ac.in/noc23_mm21/preview.