OPEN ELECTIVE I, SEMESTER V

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OPEN ELECTIVE II, SEMESTER VII

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OBJECTIVE:

- To impart knowledge on the principle and design of control of Indoor/ particulate/ gaseous air pollutant and its emerging trends.

UNIT I INTRODUCTION
Structure and composition of Atmosphere – Definition, Scope and Scales of Air Pollution – Sources and classification of air pollutants and their effect on human health, vegetation, animals, property, aesthetic value and visibility- Ambient Air Quality and Emission standards.

UNIT II METEOROLOGY

UNIT III CONTROL OF PARTICULATE CONTAMINANTS

UNIT IV CONTROL OF GASEOUS CONTAMINANTS

UNIT V INDOOR AIR QUALITY MANAGEMENT
Sources, types and control of indoor air pollutants, sick building syndrome and Building related illness- Sources and Effects of Noise Pollution – Measurement – Standards –Control and Preventive measures.

OUTCOMES:
The students completing the course will have
- an understanding of the nature and characteristics of air pollutants, noise pollution and basic concepts of air quality management
- ability to identify, formulate and solve air and noise pollution problems
- ability to design stacks and particulate air pollution control devices to meet applicable standards.
- Ability to select control equipments.
- Ability to ensure quality, control and preventive measures.

TOTAL: 45 PERIODS

TEXTBOOKS:

REFERENCES:
OBJECTIVES:
- To learn about the concept of cloud and utility computing.
- To have knowledge on the various issues in cloud computing.
- To be familiar with the lead players in cloud.
- To appreciate the emergence of cloud as the next generation computing paradigm.

UNIT I  INTRODUCTION TO CLOUD COMPUTING

UNIT II  VIRTUALIZATION

UNIT III  CLOUD ARCHITECTURE, SERVICES AND STORAGE

UNIT IV  RESOURCE MANAGEMENT AND SECURITY IN CLOUD

UNIT V  CASE STUDIES

OUTCOMES:
On Completion of the course, the students should be able to:
- Articulate the main concepts, key technologies, strengths and limitations of cloud computing.
- Learn the key and enabling technologies that help in the development of cloud.
- Develop the ability to understand and use the architecture of compute and storage cloud, service and delivery models.
- Explain the core issues of cloud computing such as resource management and security.
- Be able to install and use current cloud technologies.
- Choose the appropriate technologies, algorithms and approaches for implementation and use of cloud.

TEXT BOOKS:

REFERENCES:

OEC551 CONTROL SYSTEMS ENGINEERING

OBJECTIVES:
- To introduce the components and their representation of control systems
- To learn various methods for analyzing the time response, frequency response and stability of the systems.
- To learn the various approach for the state variable analysis.

UNIT I SYSTEMS COMPONENTS AND THEIR REPRESENTATION
Control System: Terminology and Basic Structure-Feed forward and Feedback control theory-Electrical and Mechanical Transfer Function Models-Block diagram Models-Signal flow graphs models-DC and AC servo Systems-Synchros-Multivariable control system

UNIT II TIME RESPONSE ANALYSIS
Transient response-steady state response-Measures of performance of the standard first order and second order system-effect on an additional zero and an additional pole-steady error constant and system- type number-PID control-Analytical design for PD,PI,PID control systems

UNIT III FREQUENCY RESPONSE AND SYSTEM ANALYSIS
Closed loop frequency response-Performance specification in frequency domain-Frequency response of standard second order system- Bode Plot - Polar Plot- Nyquist plots-Design of compensators using Bode plots-Cascade lead compensation-Cascade lag compensation-Cascade lag-lead compensation

UNIT IV CONCEPTS OF STABILITY ANALYSIS

UNIT V CONTROL SYSTEM ANALYSIS USING STATE VARIABLE METHODS
State variable representation-Conversion of state variable models to transfer functions-Conversion of transfer functions to state variable models-Solution of state equations-Concepts of Controllability and Observability-Stability of linear systems-Equivalence between transfer function and state variable representations-State variable analysis of digital control system-Digital control design using state feedback.

OUTCOMES:
TOTAL:45 PERIODS
Upon completion of the course, the student should be able to:

- Identify the various control system components and their representations.
- Analyze the various time domain parameters.
- Analysis the various frequency response plots and its system.
- Apply the concepts of various system stability criterions.
- Design various transfer functions of digital control system using state variable models.

TEXT BOOK:

REFERENCES

OIC501 BASIC CONTROL THEORY

OBJECTIVES:
- To understand the use of transfer function models for analysis physical systems and introduce the control system components.
- To provide adequate knowledge in the time response of systems and steady state error analysis.
- To accord basic knowledge in obtaining the open loop and closed-loop frequency responses of systems.
- To introduce stability analysis
- To introduce state variable representation of physical systems

UNIT I SYSTEMS AND THEIR REPRESENTATION
Basic elements in control systems – Open and closed loop systems – Electrical analogy of mechanical and thermal systems – Transfer function – Block diagram reduction techniques.

UNIT II TIME RESPONSE

UNIT III FREQUENCY RESPONSE

UNIT IV STABILITY AND COMPENSATOR DESIGN
Characteristics equation – Routh Hurwitz criterion – controller design.

UNIT V STATE VARIABLE ANALYSIS

TOTAL: 45 PERIODS
OUTCOMES:

- Ability to understand and apply control theory to engineering problems.

TEXT BOOKS:


REFERENCES:


OME551 ENERGY CONSERVATION AND MANAGEMENT L T P C
3 0 0 3

OBJECTIVES:

At the end of the course, the student is expected to

- understand and analyse the energy data of industries
- carryout energy accounting and balancing
- conduct energy audit and suggest methodologies for energy savings and
- utilise the available resources in optimal ways

UNIT I INTRODUCTION


UNIT II ELECTRICAL SYSTEMS


UNIT III THERMAL SYSTEMS


UNIT IV ENERGY CONSERVATION IN MAJOR UTILITIES

Pumps, Fans, Blowers, Compressed Air Systems, Refrigeration and Air Conditioning Systems – Cooling Towers – D.G. sets

UNIT V ECONOMICS

Energy Economics – Discount Rate, Payback Period, Internal Rate of Return, Net Present Value, Life Cycle Costing –ESCO concept
OUTCOMES:
Upon completion of this course, the students can able to analyse the energy data of industries.
- Can carryout energy accounting and balancing
- Can suggest methodologies for energy savings

TEXT BOOKS:
1. Energy Manager Training Manual (4 Volumes) available at www.energymanager

REFERENCES:

OCY552 FUEL CELL CHEMISTRY L T P C
3 0 0 3

OBJECTIVES
- To create awareness about alternate clean fuel available.
- To familiarize the students with the concepts and chemistry of fuel cell

UNIT I INTRODUCTION 9
Overview of fuel cells: Low and high temperature fuel cells; Fuel cell thermodynamics - heat, work potentials, prediction of reversible voltage, fuel cell efficiency.

UNIT II FUEL CELL KINETICS 9
Fuel cell reaction kinetics - electrode kinetics, overvoltage, Tafel equation, charge transfer reaction, exchange currents, electro catalysis - design, activation kinetics, Fuel cell charge and mass transport - flow field, transport in electrode and electrolyte.

UNIT III CHARACTERIZATION TECHNIQUES 9
Fuel cell characterization - in-situ and ex-situ characterization techniques, i-V curve, frequency response analysis; Fuel cell modeling and system integration: - 1D model – analytical solution and CFD models.

UNIT IV RENEWABLE SOURCES 9
Balance of plant; Hydrogen production from renewable sources and storage; safety issues, cost expectation and life cycle analysis of fuel cells.

UNIT V APPLICATIONS OF FUEL CELL 9
Fuel cell power plants: fuel processor, fuel cell power section (fuel cell stack), power conditioner; automotive applications, portable applications

TOTAL: 45 PERIODS
OUTCOME

- Students will be aware of alternate energy sources and its importance of it.

TEXTBOOKS


REFERENCES


OCE552 GEOGRAPHIC INFORMATION SYSTEM 3 0 0 3

OBJECTIVES:

- To introduce the fundamentals and components of Geographic Information System
- To provide details of spatial data structures and input, management and output processes.

UNIT I  FUNDAMENTALS OF GIS
Introduction to GIS - Basic spatial concepts - Coordinate Systems - GIS and Information Systems - Definitions - History of GIS - Components of a GIS - Hardware, Software, Data, People, Methods - Proprietary and open source Software - Types of data - Spatial, Attribute data - types of attributes - scales/levels of measurements.

UNIT II  SPATIAL DATA MODELS

UNIT III  DATA INPUT AND TOPOLOGY

UNIT IV  DATA ANALYSIS
Vector Data Analysis tools - Data Analysis tools - Network Analysis - Digital Education models - 3D data collection and utilisation.

UNIT V  APPLICATIONS

TOTAL: 45 PERIODS

OUTCOME:

This course equips the student to

- Have basic idea about the fundamentals of GIS.
- Understand the types of data models.
• Get knowledge about data input and topology.
• Gain knowledge on data quality and standards.
• Understand data management functions and data output

TEXT BOOKS:

REFERENCE:

OMD552 HOSPITAL WASTE MANAGEMENT

OBJECTIVES:
The student should be made to:
• Know about the healthcare hazard control and accidents
• Understand biomedical waste management
• Learn the facility guidelines, infection control and patient safety.

UNIT I HEALTHCARE HAZARD CONTROL AND UNDERSTANDING ACCIDENTS

UNIT II BIOMEDICAL WASTE MANAGEMENT
Biomedical Waste Management: Types of wastes, major and minor sources of biomedical waste, Categories and classification of biomedical waste, hazard of biomedical waste, need for disposal of biomedical waste, waste minimization, waste segregation and labeling, waste handling and disposal.

UNIT III HAZARDOUS MATERIALS

UNIT IV FACILITY SAFETY

UNIT V INFECTION CONTROL, PREVENTION AND PATIENT SAFETY

TOTAL: 45 PERIODS

OUTCOMES:
- After successful completion of the course, the students will be able to know the concepts of healthcare waste management, its prevention and safety.

REFERENCES:

OAI552 PARTICIPATORY WATER RESOURCES MANAGEMENT

OBJECTIVE:
- To gain an insight on local and global perceptions and approaches on participatory water resource management

UNIT I FUNDAMENTALS: SOCIOLOGY AND PARTICIPATORY APPROACH
Sociology – Basic concepts – Perspectives- Social Stratification – Irrigation as a Socio technical Process - Participatory concepts– Objectives of participatory approach

UNIT II UNDERSTANDING FARMERS PARTICIPATION

UNIT III ISSUES IN WATER MANAGEMENT

UNIT IV PARTICIPATORY WATER CONSERVATION

UNIT V PARTICIPATORY WATERSHED DEVELOPMENT
Concept and significance of watershed - Basic factors influencing watershed development — Principles of watershed management - Definition of watershed management – Identification of problems - Watershed approach in Government programmes — People’s participation – Entry point activities - Evaluation of watershed management measures.

TOTAL: 45 PERIODS

OUTCOMES:
The students will be able to
- Gain knowledge on various processes involved in participatory water resource management.
- Understand farmers participation in water resources management.
• Aware of the issues related to water conservation and watershed development
• Get knowledge in participatory water conservation
• Understand concept, principle, approach of watershed management.

TEXTBOOKS:

REFERENCE:

ORO551 RENEWABLE ENERGY SOURCES

OBJECTIVES:
• To get exposure on solar radiation and its environmental impact to power.
• To know about the various collectors used for storing solar energy.
• To know about the various applications in solar energy.
• To learn about the wind energy and biomass and its economic aspects.
• To know about geothermal energy with other energy sources.

UNIT I PRINCIPLES OF SOLAR RADIATION 10
Role and potential of new and renewable source, the solar energy option, Environmental impact of solar power, physics of the sun, the solar constant, extraterrestrial and terrestrial solar radiation, solar radiation on tilted surface, instruments for measuring solar radiation and sun shine, solar radiation data.

UNIT II SOLAR ENERGY COLLECTION 8
Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis, advanced collectors.

UNIT III SOLAR ENERGY STORAGE AND APPLICATIONS 7
Different methods, Sensible, latent heat and stratified storage, solar ponds. Solar Applications - solar heating/cooling technique, solar distillation and drying, photovoltaic energy conversion.

UNIT IV WIND ENERGY 10

UNIT V GEOTHERMAL ENERGY: 9
Resources, types of wells, methods of harnessing the energy, potential in India. OCEAN ENERGY: OTEC, Principles utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants, and their economics. DIRECT ENERGY CONVERSION: Need for DEC, Carnot cycle, limitations, principles of DEC.

TOTAL : 45 PERIODS
OUTCOMES:
- Understanding the physics of solar radiation.
- Ability to classify the solar energy collectors and methodologies of storing solar energy.
- Knowledge in applying solar energy in a useful way.
- Knowledge in wind energy and biomass with its economic aspects.
- Knowledge in capturing and applying other forms of energy sources like wind, biogas and geothermal energies.

TEXT BOOKS:

REFERENCES:

OGI751 CLIMATE CHANGE AND ITS IMPACT L T P C 3 0 0 3

OBJECTIVES:
- To understand the basics of weather and climate
- To have an insight on Atmospheric dynamics and transport of heat
- To develop simple climate models and evaluate climate changes using models

UNIT I BASICS OF WEATHER AND CLIMATE: 9

UNIT II ATMOSPHERIC DYNAMICS: 9

UNIT III GLOBAL CLIMATE 9

UNIT IV CLIMATE SYSTEM PROCESSES


UNIT V CLIMATE CHANGE MODELS


TOTAL: 45 Periods

OUTCOMES:
At the end of the course the student will be able to understand
- The concepts of weather and climate
- The principles of Atmospheric dynamics and transport of heat and air mass
- The develop simple climate models and to predict climate change

TEXTBOOKS:

OME751 DESIGN OF EXPERIMENTS

3 0 0 3

OBJECTIVE:
- To impart knowledge on various types of experimental designs conduct of experiments and data analysis techniques.

UNIT I FUNDAMENTALS OF EXPERIMENTAL DESIGNS

Hypothesis testing – single mean, two means, dependant/ correlated samples – confidence intervals, Experimentation – need, Conventional test strategies, Analysis of variance, F-test, terminology, basic principles of design, steps in experimentation – choice of sample size – Normal and half normal probability plot – simple linear and multiple linear regression, testing using Analysis of variance.

UNIT II SINGLE FACTOR EXPERIMENTS

Completely Randomized Design- effect of coding the observations- model adequacy checking- estimation of model parameters, residuals analysis- treatment comparison methods-Duncan’s multiple range test, Newman-Keuel’s test, Fisher’s LSD test, Tukey’s test-testing using contrasts- Randomized Block Design – Latin Square Design- Graeco Latin Square Design –Applications.

UNIT III FACTORIAL DESIGNS
Main and Interaction effects - Two and three factor full factorial designs - Fixed effects and random effects model - Rule for sum of squares and Expected Mean Squares - $2^K$ Design with two and three factors - Yate’s Algorithm- fitting regression model- Randomized Block Factorial Design - Practical applications.

UNIT IV SPECIAL EXPERIMENTAL DESIGN
Blocking and Confounding in $2^K$ Designs- blocking in replicated design- $2^K$ Factorial Design in two blocks- Complete and partial confounding- Confounding $2^K$ Design in four blocks- Two level Fractional Factorial Designs- one-half fraction of $2^K$ Design, design resolution, Construction of one-half fraction with highest design resolution, one-quarter fraction of $2^K$ Design

UNIT V TAGUCHI METHODS
Design of experiments using Orthogonal Arrays, Data analysis from Orthogonal experiments- Response Graph Method, ANOVA- attribute data analysis- Robust design- noise factors, Signal to noise ratios, Inner/outer OA design.

TOTAL: 45 PERIODS

OUTCOME:
• Able to apply experimental techniques to practical problems to improve quality of processes / products by optimizing the process / product parameters.

TEXT BOOK:

REFERENCES:

OCE751 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

OBJECTIVE:
• To impart the knowledge and skills to identify, assess and mitigate the environmental and social impacts of developmental projects

UNIT I INTRODUCTION

UNIT II ENVIRONMENTAL ASSESSMENT
Screening and Scoping in EIA – Drafting of Terms of Reference,Baseline monitoring, Prediction and Assessment of Impact on land, water, air, noise, flora and fauna - Matrices – Networks – Checklist Methods - Mathematical models for Impact prediction.

UNIT III ENVIRONMENTAL MANAGEMENT PLAN
UNIT IV   SOCIO ECONOMIC ASSESSMENT
Baseline monitoring of Socio economic environment – Identification of Project Affected Personal – Rehabilitation and Resettlement Plan- Economic valuation of Environmental impacts – Cost benefit Analysis -

UNIT V    CASE STUDIES

OUTCOMES:
The students completing the course will have ability to
• carry out scoping and screening of developmental projects for environmental and social assessments
• explain different methodologies for environmental impact prediction and assessment
• plan environmental impact assessments and environmental management plans
• evaluate environmental impact assessment reports

TEXTBOOKS:

REFERENCES:

OAE751    FUNDAMENTALS OF COMBUSTION
L T P C
3 0 0 3

OBJECTIVE:
• To make the student understand the fundamentals of combustion and to teach them combustion in different regions like basic flame to gas turbine engines to rocket engines and finally how it is done in supersonic speeds.

UNIT I    INTRODUCTION TO COMBUSTION
Thermo-chemical equations –Heat of formation –Activation energy -Multi-step reactions - Heat of reaction -first order, second order and third order reactions – Calculation of adiabatic flame
UNIT II  BASICS OF CHEMICAL KINETICS AND FLAMES  9

UNIT III  COMBUSTION IN GAS TURBINE ENGINES  9

UNIT IV  COMBUSTION IN ROCKETS  9

UNIT V  SUPERSONIC COMBUSTION  (Qualitative Treatment only)  9

TOTAL: 45 PERIODS

OUTCOMES:

- The student will be in a position to understand the detailed mechanism of Aerospace Vehicles and Aircraft Engines.
- The student will be able to analyse and impart the combustion processes that occur in Aircraft Engines and Rocket Vehicles.

TEXT BOOK:


REFERENCES:


UNIT II  IMPLICATIONS OF BUILDING TECHNOLOGIES EMBODIED ENERGY OF BUILDINGS  9

UNIT III  COMFORTS IN BUILDING  9

UNIT IV  UTILITY OF SOLAR ENERGY IN BUILDINGS  9

UNIT V  GREEN COMPOSITES FOR BUILDINGS  9

TOTAL: 45 PERIODS

TEXT BOOKS:

REFERENCES:
3. Fundamentals of Integrated Design for Sustainable Building By Marian Keeler, Bill Burke

OME754  INDUSTRIAL SAFETY  L T P C
3 0 0 3

OBJECTIVES:
- To impart knowledge on safety engineering fundamentals and safety management practices.

UNIT I  INTRODUCTION  9
Evolution of modern safety concepts – Fire prevention – Mechanical hazards – Boilers, Pressure vessels, Electrical Exposure.

UNIT II  CHEMICAL HAZARDS  9
Chemical exposure – Toxic materials – Ionizing Radiation and Non-ionizing Radiation - Industrial Hygiene – Industrial Toxicology.
UNIT III  ENVIRONMENTAL CONTROL  9
Industrial Health Hazards – Environmental Control – Industrial Noise - Noise measuring instruments, Control of Noise, Vibration, - Personal Protection.

UNIT IV  HAZARD ANALYSIS  9
System Safety Analysis –Techniques – Fault Tree Analysis (FTA), Failure Modes and Effects Analysis (FMEA), HAZOP analysis and Risk Assessment

UNIT V  SAFETY REGULATIONS  9

TOTAL : 45 PERIODS

OUTCOMES:
- Students must be able to identify and prevent chemical, environmental mechanical, fire hazard through analysis and apply proper safety techniques on safety engineering and management.

TEXT BOOK:

REFERENCES:

ORO751  NANO COMPUTING  L T P C
3  0  0  3

OBJECTIVES:
The student should be made to:
- Learn nano computing challenges
- Be familiar with the imperfections
- Be exposed to reliability evaluation strategies
- Learn nano scale quantum computing
- Understand Molecular Computing and Optimal Computing

UNIT I  NANOCOMPUTING-PROSPECTS AND CHALLENGES  9

UNIT II  NANOCOMPUTING WITH IMPERFECTIONS  9
### UNIT III  RELIABILITY OF NANOCOMPUTING

### UNIT IV  NANOSCALE QUANTUM COMPUTING

### UNIT V  QCADESIGNER SOFTWARE AND QCA IMPLEMENTATION

TOTAL: 45 PERIODS

#### OUTCOMES:
Upon completion of the course, the student should be able to:
- Discuss nano computing challenges.
- Handle the imperfections.
- Apply reliability evaluation strategies.
- Use nano scale quantum computing.
- Utilize Molecular Computing and Optimal Computing.

#### TEXT BOOK:

#### REFERENCES:

### OML753  SELECTION OF MATERIALS

#### OBJECTIVES:
The subject exposes students to the basics parameter for selection of materials and different classes of materials, manufacturing processes and their properties, applications of materials.

#### UNIT I  ENGINEERING MATERIALS

#### UNIT II  MATERIAL PROPERTIES

UNIT III       MANUFACTURING PROCESSING AND ECONOMIC ANALYSIS

UNIT IV      MATERIALS SELECTION CHARTS AND TESTING

UNIT V         APPLICATIONS AND USES

OUTCOMES:
• Understand different types of availability materials
• Easy and effective way to select required materials
• Ability to identify the material properties

TEXT BOOKS:

REFERENCES:

OML751       TESTING OF MATERIALS
L T P C
3 0 0 3

OBJECTIVE:
• To understand the various destructive and non destructive testing methods of materials and its industrial applications.

UNIT I       INTRODUCTION TO MATERIALS TESTING
Overview of materials, Classification of material testing, Purpose of testing, Selection of material, Development of testing, Testing organizations and its committee, Testing standards, Result Analysis, Advantages of testing.
UNIT II MECHANICAL TESTING
Introduction to mechanical testing, Hardness test (Vickers, Brinell, Rockwell), Tensile test, Impact test (Izod, Charpy) - Principles, Techniques, Methods, Advantages and Limitations, Applications. Bend test, Shear test, Creep and Fatigue test - Principles, Techniques, Methods, Advantages and Limitations, Applications.

UNIT III NON DESTRUCTIVE TESTING

UNIT IV MATERIAL CHARACTERIZATION TESTING
Macroscopic and Microscopic observations, Optical and Electron microscopy (SEM and TEM) - Principles, Types, Advantages and Limitations, Applications. Diffraction techniques, Spectroscopic Techniques, Electrical and Magnetic Techniques- Principles, Types, Advantages and Limitations, Applications.

UNIT V OTHER TESTING

TOTAL: 45 PERIODS

OUTCOMES:
- Identify suitable testing technique to inspect industrial component
- Ability to use the different technique and know its applications and limitations

TEXT BOOKS:

REFERENCES:
B.Tech Chemical and Electrochemical Engineering is currently offered only by Anna University and its affiliated colleges including CECRI Karaikudi. Ques. What is the advantage of B.Tech Chemical and Electrochemical Engineering over other Chemical Engineering courses? Ans. This course is a highly research based course and involves the knowledge of both Chemical and Electrochemical fields. So, the candidates pursuing this course will have an edge over the other Chemical Engineering candidates. Ques. Chemical Engineering at NIT Raipur will definitely be a good choice. As far as facilities and other parameters are concerned, here’s what you should know. Highlights: The department has well-equipped laboratories and classrooms. Under choice based credit system branch: chemical engineering semester: first. Code No. Eng 1101 eng 1102 eng 1103 eng 1104 eng 1106. 1. Petroleum Refinery Engineering 2. Energy Engineering 3. Electrochemical Engineering 4. Corrosion Engineering 5. Process Dynamics and Control 6. Reaction Engineering. Andhra university :: a.u.college of engineering(a) scheme of instruction & examination. VI/VI b.tech & M.tech(six year double degree course) (with effect from 2015-16 admitted batch onwards) under choice based credit system branch: chemical engineering semester: first & second. ANNA UNIVERSITY, CHENNAI AFFILIATED INSTITUTIONS REGULATIONS 2017 M.E. MANUFACTURING ENGINEERING CHOICE BASED CREDIT SYSTEM PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) : I. To prepare students to excel in research or to succeed in Manufacturing engineering profession through global, rigorous post graduate education. II. To provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve Manufacturing engineering problems III. To train students with good scientific and engineering knowledge so as to comprehend, analyze, design, and create novel pro