Minor Degree Courses
Offered by
Department of Chemical Engineering

The department of Chemical Engineering offers the following minor degree courses for the students of undergraduate B. Tech. program of other departments

Minor 1: Food Processing Technology		
PE-1	ECH-101	Fundamentals of Food Science and Human Nutrition
PE-3	ECH-301	Principals of Food Preservation
PE-5	ECH-501	Bakery Technology
PE-7	ECH-701	Dairy Technology
PE-9	ECH-901	Food Packaging & Storage Engineering
Minor 2: Green Hydrogen Technology		
PE-1	ECH-102	Hydrogen and Fuel Cell Technology
PE-3	ECH-302	Green Hydrogen Production Techniques
PE-5	ECH-502	Biohydrogen Production
PE-7	ECH-702	Hydrogen Storage and Transport
PE-9	ECH-902	Cryogenic Hydrogen Technology
Minor 3: Advanced Materials Engineering		
PE-1	ECH-103	Advanced Polymeric Materials
PE-3	ECH-303	Advanced Methods of Materials Characterisation
PE-5	ECH-503	Advanced Composite Materials
PE-7	ECH-703	Energy Storage Materials
PE-9	ECH-903	Materials For Sustainable Engineering

1. Minor degree courses are optional, but it will be helpful to align the need of industries.
2. Students can only opt for one minor degree course during his/her studies of the B. Tech. program
3. If students complete all 5 PE (professional elective) category courses offered for the minor degree (total 20 credit) from the other department for minor degree, he/shell get a B. tech. degree in his/her own branch.
4. No extra fee for a minor degree course will be charged by the students
5. In case if a student is unable to complete all 5 PE courses as offered by the other department for minor degree at the time of completion of B. Tech. program in his/her own branch then student will get B. Tech. degree in his/her own branch without completing the minor degree course from other Department.
6. The minor degree course may be offered by the department through MOOC, as per the guidelines in B. Tech. ordinance 3.0 for the MOOC course.

Minor Degree 1: Food Processing Technology

Category	Subject Code	Subject Title	Credit			Total Credit
			L	T	P	
PE-1	ECH-101	Fundamentals of Food Science and Human Nutrition	3	1	0	4
PE-3	ECH-301	Principals of Food Preservation	3	1	0	4
PE-5	ECH-501	Bakery Technology	3	0	2	4
PE-7	ECH-701	Dairy Technology	3	0	2	4
PE-9	ECH-901	Food Packaging & Storage Engineering	3	1	0	4
					Total	**20**

ECH-101: FUNDAMENTALS OF FOOD SCIENCE AND HUMAN NUTRITION

Course Category : Programme Elective (PE-1)

Pre-requisite Subject : NIL

Contact hours/week : Lecture: 3, Tutorial:1, Practical: 0

No of Credits : 4

Course Assessment Methods : Continuous assessment through tutorials, attendance, home assignments, quizzes, and one minor tests and One Major Theory Examination.

Course Objectives : To impart the knowledge of

a. Fundamental concepts of food technology and recent trends of food processing industries in India.
b. Role of food in human nutrition and protection from various ailments.
c. Basic concepts of biology, chemistry, microbiology and biochemistry of foods

Course Outcome : At the end of the course the students will be able to:

1. *Explain* the fundamental principles of food science, including food composition, properties, and classification.
2. *Describe* the digestion, absorption, and metabolism of nutrients and the role of major and minor nutrients in human health.
3. *Analyze* the nutritional requirements across different life stages and evaluate factors influencing dietary needs.
4. *Apply* the basic concepts of food preservation, processing, and safety in handling, storage, and preparation of food.
5. *Evaluate* the impact of food choices on human health, including the role of diet in the prevention and management of diseases.
6. *Develop* balanced dietary plans using nutritional guidelines and food group recommendations for individuals with specific needs.

UNIT I: INTRODUCTION 9

Status of food processes industry in India and globally, Factors affecting the growth of Indian food industries, Opportunities and challenges in Indian food industry, Market scenario of various segments of food industry, Scope and Job opportunities for food technologists

UNIT 2: COMPOSITION OF FOODS 9

Definition, classification and functions of foods, constituents of food, , Food spoilage, causes of spoilage, Basics about food preservation, Desirable and potentially undesirable food constituents and their importance, General causes of loss of nutrients during processing and storage.

UNIT 3: CONCEPT OF FOOD NUTRITION AND HUMAN HEALTH 9

Human nutrition and health, Recommended Dietary Allowances, Factors affecting bioavailability of nutrients, Enrichment, Fortification, Restoration and Supplementation of foods, Digestion and absorption of bio-molecules, common nutritional deficiencies such as PEM, iron, vitamin A, iodine, calcium and vitamin D, zinc etc., Nutritive value and its assessment.

UNIT 4: BASIC BIOLOGY &MICROBIOLOGICAL ASPECTS OF FOOD 9

Living cells, organization of living system, characteristics, Plant and animal diversity, Basics about general microbiology: Culture, media and their types, features of growth in nutrient broth and agar, Staining techniques, Culture preservation techniques, Characterization, classification and identification of microorganisms, Microscopy, Morphology and Structure, Growth, Reproduction and Cultivation of microorganisms, Pure culture and its isolation, Control of microorganisms. Role of microorganisms in food spoilage and preservation.

References

1. C. GOPALAN, B. V. RAMA SASTRI, S. C. BALASUBRAMANIAN, "Nutritive Value of Indian Foods" , ICMR
2. Lillian Hoagland Meyer, "Food Chemistry", CBS PUBLISHERS
3. Amihud Kramer, Bernard A. Twigg, "Quality Control For The Food Industry Fundamentals & Applications", Medtech; 3rd edition (1 March 2017).
4. N. Shakuntala Manay, "Foods Facts and Principles", NEW AGE (1 January 2008)
5. Michael **Pelczar, Jr, "Microbiology",** McGraw Hill Education; 5th edition (20 April 2001)
6. David **L. Nelson, Michael Cox, "Lehninger Principles of Biochemistry",** WH Freeman; 7th ed. 2017 edition (1 January 2017)

ECH-301: PRINCIPLES OF FOOD PRESERVATION

Course Category : Programme Elective -III (PE-3)

Pre-requisite Subject : NIL

Contact hours/week : Lecture: 3, Tutorial:1, Practical: 0

No of Credits : 4

Course Assessment Methods : Continuous assessment through tutorials, attendance, home assignments, quizzes, and one minor tests and One Major Theory Examination.

Course Objectives : To impart the knowledge of

a. Basic knowledge of Principles of Food Preservation
b. Depth knowledge of Technologies based on these principles
c. Working principles, Advantages and Limitations of these processes

Course Outcome : At the end of the course the students will be able to:

1. *Explain the fundamental causes of food spoilage and the need for preservation techniques.*
2. *Identify and describe various traditional and modern food preservation methods, including thermal, chemical, refrigeration, freezing, drying, and irradiation techniques.*
3. *Apply preservation techniques to different food products to enhance shelf life while maintaining safety and quality.*
4. *Analyze the effects of preservation methods on nutritional quality, sensory attributes, and microbial stability of food products.*
5. *Evaluate the suitability of specific preservation methods based on food type, storage conditions, economic considerations, and regulatory standards.*
6. *Design basic food preservation strategies by integrating scientific principles with technological applications to solve real-world food storage and safety problems.*

UNIT I: INTRODUCTION 9

Basic considerations: Aims and objectives of preservation & processing of foods, Wastage of Foods, Food Safety

and Food Security, Causes of quality deterioration and spoilage of perishable foods. Characteristics of tissue and non-tissue foods, Degree of perishability of unmodified foods, Concept of Intermediate moisture foods, Basic Principles of Food Preservation and Methods Involved

UNIT 2: PRESERVATION OF FOODS BY LOW TEMPERATURES 9

Chilling temperatures: Consideration relating to storage of foods at chilling temperatures, Applications and procedures, Controlled and Modified atmosphere storage of foods, Post storage Handling of foods. Advantages and Limitations of Chilling Process. Freezing temperatures: Freezing process, Slow and fast freezing of foods and its consequence, other occurrences associated with freezing of foods. Technological aspects of Pre freezing, Actual freezing, Frozen storage and Thawing of foods. Technologies involved and their working principles.

UNIT 3: PRESERVATION OF FOODS BY HIGH TEMPERATURES 9

Basic concepts in thermal destruction of microorganisms. D, Z, F values. Heat resistance and thermophic microorganisms. Thermal Death Time Curve and its implications. Cooking, Blanching, Pasteurization and Sterilization of foods. General process of Caning of foods, Spoilage in Canned foods. Canning in Retortable Pouches. Assessing adequacy of thermal processing of foods.

UNIT 4: PRESERVATION OF FOODS BY WATER REMOVAL 9

Basic Principles, Technological aspects and application of evaporative concentration process; Freeze concentration and membrane process for food concentrations and their applications along with advantages and limitations. Basic Principles, Technological aspects and application of drying and dehydration of foods, Cabinet, tunnel, belt, bin, drum, spray, vacuum, foam mat, fluidized-bed and freeze drying of foods. Basic Principles, working principle and equipments involved. Advantages and Limitations of these processes.

References

1. Norman N.Potter, Joseph H.Hotchkiss,"FoodScience",5thEdition,CBS Publishers & Distributor Pvt. Ltd. (2007)
2. Marcus Karel,Owen R. Fennema, Daryl B.Lund, "Principles of Food Science, Part-II, Physical Principles of Food Preservation, M.Dekker (2008)
3. Norman W.Desrosier, Technology of Food Preservation, Medtech, Scientific International Pvt. Ltd New Delhi (2018)
4. C.R.Stumbo," Thermobacteriology in FoodProcessing"2nd Edition,Academic Press (1973)

ECH-501: BAKERY TECHNOLOGY

Course Category	: Programme Elective (PE-5)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:0, Practical: 2
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes, and one minor tests and One Major Theory Examination.
Course Objectives	: To impart the knowledge of a) Fundamental knowledge of bakery products b) Basic knowledge about machinery and equipments involved c) Brief introduction of recent developments in bakery product technology.
Course Outcome	: At the end of the course the students will be able to:

1. *Describe the basic principles of baking, including the function of ingredients, fermentation, and leavening processes.*
2. *Explain the manufacturing processes of bakery products such as bread, biscuits, cakes, and pastries, including process control parameters.*
3. *Apply standard formulations and unit operations to prepare common bakery products under hygienic and safe conditions.*
4. *Analyze the effect of ingredients, formulation, and processing conditions on the texture, flavor, and shelf life of bakery products.*
5. *Evaluate the quality of bakery products using physicochemical and sensory evaluation techniques.*
6. *Develop innovative or health-oriented bakery products using alternative ingredients and modified processing techniques to meet consumer demands.*

UNIT I: INTRODUCTION 9

Wheat flour and wheat flour treatments, Grade of flour, constituents of flour, ageing of flour, Tests for flour quality.

Yeast: Characteristics, Preparation, Handling & Storage, Adequacy for use in bakery industry.

Ingredients, Technology and quality parameters for baked products: Bread, Biscuits and cakes.

UNIT 2: BAKERY EQUIPMENT AND MACHINERY 9

Different types of Mixers, kneaders and cutters. Different types of ovens. Packaging machinery for bread and biscuits. Quality control in bakery industry. Quality control of raw materials. Quality control of finished products. Quality control of packaging materials.

UNIT 3: TECHNOLOGY OF BREAD MAKING 9

Different methods, process steps and their significance. Characteristics of good bread. Defects in bread their causes and remedies.

UNIT 4: TECHNOLOGY OF CAKES MANUFACTURE 9

Different cake making processes. Sugar batter method, Flour batter method, Modified sugar batter method Whipping method, Blending method etc. Process steps and their significance

Importance of baking time and temperature. Recipe balancing. Defects in cakes, their causes and remedies..

References

1. Pyler & Gorton: Baking Science and Technology, 4th Edition, Sosland Pub Co (2009)
2. Samuel A. Matz: Bakery Technology and Engineering (Paperback) Springer US (2019)
3. Samuel A. Matz: Cookie and Cracker Technology, 3 rd Edition, Van Nostrand Reinhold Inc.,U.S(1993)
4. H. Faridi: The Science of Cookie and Cracker Production, Chapman & Hall (1997)

List of Practical

1. Preparation of Bread/ Test Baking.
2. Preparation of Sweet Buns
3. Preparation of Pizza base.
4. Preparation of Biscuits
5. Preparation of Nan-Khatai
6. Preparation of Cookies
7. Preparation of Cakes (Eggs/ Eggless)
8. Preparation of Pastries
9. Preparation of Laminated and Puffed products

ECH-701: DAIRY TECHNOLOGY

Course Category : Programme Elective (PE-7)
Pre-requisite Subject : NIL
Contact hours/week : Lecture: 3, Tutorial:0, Practical: 2
No of Credits : 4

Course Assessment Methods : Continuous assessment through tutorials, attendance, home assignments, quizzes, and one minor tests and One Major Theory Examination.

Course Objectives : To impart the knowledge of

a) Technologies of processing of milk and milk products
b) Machinery and equipments involved.
c) Hygiene and sanitation practices in milk plant.

Course Outcome : At the end of the course the students will be able to:

1. *Explain the composition and properties of milk from various sources and its relevance to processing and product development.*
2. *Apply standard techniques for milk collection, preservation, pasteurization, and homogenization in accordance with quality and safety regulations.*
3. *Analyze the operational principles of equipment used in dairy processing, including separators, homogenizers, and evaporators.*
4. *Evaluate different dairy processing methods for the production of value-added products like cheese, yogurt, butter, and milk powder.*
5. *Assess the implementation of quality control systems and food safety standards (like FSSAI, BIS, and HACCP) in dairy industries.*
6. *Design small-scale dairy processing systems or unit operations considering hygiene, energy efficiency, and product quality.*

UNIT I: INTRODUCTION 9

Fluid Milk: Composition of milk and factor affecting it. Physico-chemical characteristics of milk and milk constituents. Production and collection, cooling and transportation of milk. Packaging storage and distribution of pasteurized milk

UNIT 2: MILK PROCESSING 9

Whole, Standardized, Toned, Double toned and skim milk. Test for milk quality and Adulteration. UHT processed milk, flavored, Sterilized milk. Cleaning and sanitization of dairy equipments. Definition, Classification, Composition and physico-chemical properties of cream. Production processes and quality control.

UNIT 3: MAKING OF DAIRY PRODUCTS 9

Butter: Definition, Classification, Composition and methods of manufacture, Packaging and storage. Butter oil/Ghee. Dairy based Ice cream: Definition, Classification and Composition, Constituents and their role. Preparation of mixes and freezing of Ice cream, Overrun, Judging, Grading, and defects of Ice cream.

UNIT 4: PRESERVATION OF DAIRY PRODUCTS 9

Evaporated and Condensed milk: Method of manufacture, Packaging and storage. Defects, Causes, and prevention. Roller and Spray Drying of milk solids. Instantization. Flow ability, Dustiness, Reconstituability, Dispersability, Wetability, Sink ability and appearance of milk powders.

References

1. De Sukumar: Outlines of Dairy Technology, 46th Edition, Oxford University Press (2019)
2. Aneja, Mathur, Chandan & A. K. Bannerji: Technology of Indian Milk Products: Dairy India Publication (2002)
3. Shivashraya Singh: Dairy Technology: Vol.01: Milk and Milk Processing,New India Publishing Agency (2013)
4. Meghwal. Goyal and Chavan: Dairy Engineering: Advanced Technologies andtheir applications, Apple Academic Press, Canada (2017)

List of Practical

1. Platform Tests of milk [COB, MBR Test, Alcohol Test, Sediment Test]
2. Determination of Fat content in Milk and Milk Products
3. Determination of SNF Content in Milk

4. Determination of Titratable Acidity in Milk
5. Determination of Overrun in Icecream
6. Preparation and Quality Testing of Butter
7. Preparation and Quality Testing of Butter oil / Ghee
8. Analysis of Adulteration in Milk and Milk products

ECH-901: FOOD PACKAGING AND STORAGE ENGINEERING

Course Category : Programme Elective (PE-9)
Pre-requisite Subject : NIL
Contact hours/week : Lecture: 3, Tutorial:1, Practical: 0
No of Credits : 4
Course Assessment Methods : Continuous assessment through tutorials, attendance, home assignments, quizzes, and one minor tests and One Major Theory Examination.
Course Objectives : To impart the knowledge of

a) Knowledge of packaging, package developments and packaging laws and regulations in food industries.
b) Knowledge of different types of packaging materials and their forms used in food packaging.
c) Knowledge about package performance and various testing of packaging materials.
d) Knowledge about storage of food and food products..

Course Outcome : At the end of the course the students will be able to:

1. *Understand the principles and functions of food packaging materials and storage systems to maintain food quality and safety.*
2. *Identify and classify various types of packaging materials and techniques used for different categories of food products.*
3. *Analyze the physical, chemical, and barrier properties of packaging materials relevant to shelf-life extension.*
4. *Evaluate the impact of storage conditions (temperature, humidity, light, etc.) on food stability and quality.*
5. *Assess regulatory, environmental, and sustainability issues associated with packaging materials and food storage technologies.*
6. *Design suitable packaging systems considering mechanical, thermal, and microbial factors for specific food products.*

UNIT I: Introduction of Packaging 9

Concept of packaging, Important functions of package, Packaging laws and regulations: Printing techniques; Package labeling: functions and regulations; Environmental aspect of food packaging

UNIT 2: Glass containers and closures 9

Glass containers and closures, Metal containers: tin-plate containers, tin free steel containers, aluminum and other metal containers. Protective lacquers and coatings for metal containers. Wooden crates, plywoods, cellulosic papers, pouches, bags and card board / corrugated paper boxes. Rigid and flexible packaging: laminates, containers and films and their mechanical sealing and barrier properties.

UNIT 3: MAKING OF DAIRY PRODUCTS 9

Selection of Packaging materials, forms and machinery for various food commodities: Fruits and vegetable and their products, Milk and milk products, Meat, fish, egg etc., cereals, pulses and oilseeds products, confectionery etc. Evaluation of quality, safety and interaction with foods of various types of packaging materials. Gas, vacuum, CAP, MAP and aseptic packaging, Tetra packing, Smart packaging, Intelligent Packaging, Active Packaging and Antimicrobial packaging, Retortable pouches, biodegradable and edibles packaging materials and films.

UNIT 4: Destructive Test 9

Destructive & Nondestructive test of rigid, semi rigid and flexible packaging material: tensile strength, compression, bursting, tear and impact test for packages, integrity testing. Cushioning effect on packaged foods, deterioration of packaged foods, shelf life study for packaged foods. Corrosion and toxicity of packaging material.

References

1. Food Packaging: Principles and Practice Robertson G.L.
2. Food Packaging Materials Mahadeviah M. and Gowramma R.V
3. Principles of Food Packaging Saclarow S. and Griffin R.C.,
4. Food and Package Engineering Scott A. Morris
5. Food Packaging and Preservation Alexandru Grumezescu Alina Maria Holban

Minor Degree 2: Green Hydrogen Technology

Category	Subject Code	Subject Title	Credit			Total Credit
			L	T	P	
PE-1	ECH-102	Hydrogen and Fuel Cell Technology	3	0	2	4
PE-3	ECH-302	Green Hydrogen Production Techniques	3	0	2	4
PE-5	ECH-502	Biohydrogen Production	3	1	0	4
PE-7	ECH-702	Hydrogen Storage and Transport	3	1	0	4
PE-9	ECH-902	Cryogenic Hydrogen Technology	3	1	0	4
					Total	**20**

ECH-102: HYDROGEN FUEL CELL TECHNOLOGY

Course Category : Program Elective – I (PE-I)

Pre-requisite Subject : Nil

Contact hours/week : Lecture: 3, Tutorial:0, Practical: 2

No of Credits :4

Course Assessment Methods Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one minor test and One Major Theory & Practical Examination.

Course Objectives The course objective is to provide the fundamental concept of hydrogen and fuel cell and relevant engineering and technologies

Course Outcome At the end of the course the students will be able to understand

1. Fundamental hydrogen production
2. Types of hydrogen
3. Manufacturing processes for hydrogen
4. Types of fuel cells and its selection
5. Performance evaluation of fuel cell
6. Fuel application and economics

Unit – I: Hydrogen – Fundamentals 9

Hydrogen as a source of energy, physical and chemical properties, salient characteristics, relevant issues and concerns Teaching Hrs. Module Weightage

Unit – II: Hydrogen Storage and Applications 9

Production of hydrogen, steam reforming, water electrolysis, gasification and woody biomass conversion, biological hydrogen production, photo dissociation, direct thermal or catalytic splitting of water, hydrogen storage options, compressed gas, liquid hydrogen, hydride, chemical storage, safety and management of hydrogen, applications of hydrogen.

Unit – III Fuel Cells- Types 9

Brief history, principle, working, thermodynamics and kinetics of fuel cell process, types of fuel cells; AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits, performance evaluation of fuel cell, comparison of battery Vs fuel cell.

Unit – IV: Fuel Cells -Application and Economics 9

Fuel cell usage for domestic power systems, large scale power generation, automobile, space applications, economic and environmental analysis on usage of fuel cell, future trends of fuel cells.

Reference Books:

1. Viswanathan, B and M Aulice Scibioh, Fuel Cells – Principles and Applications, Universities Press
2. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma
3. Bent Sorensen (Sorensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier Academic Press, UK
4. Kordesch, K and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany

5. Hart, A.B and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, New York Ltd., London
6. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA

List of Practical

1. Draw Characteristics of fuel cell with the help of resistive load or DC-DC converter
2. Output power variation of fuel cell with change in Hydrogen supply
3. Evaluate Fuel cell system performance with only DC load connected to the charge controller with battery bank
4. Evaluate Fuel cell System performance with only AC load connected to the inverter with battery bank
5. Evaluate Output power variation of fuel cell with change in temperature
6. To study the evolution of fuel cell advancement
7. To study the construction and working of solid oxide fuel cell
8. To study the construction and working of protons exchange fuel cell

ECH-302: GREEN HYDROGEN PRODUCTION TECHNIQUES

Course Category : Program Elective – III (PE-II)
Pre-requisite Subject : Nil
Contact hours/week : Lecture: 3, Tutorial:0, Practical: 2
No of Credits :4
Course Assessment Methods Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one minor test and One Major Theory & Practical Examination.
Course Objectives Student able to understand the production process of hydrogen, thermodynamic feasibility of processes, economical and ecological analysis of process
Course Outcome At the end of the course the students will be able to

1. Select the process for hydrogen production from renewable and non-renewable resources
2. Understand the principals of electrolysis process and steam reforming process
3. Do the thermodynamic analysis of process
4. Calculate process and electrolyzer efficiency
5. Economic analysis of process
6. Ecological analysis of process

Unit-I: Production Process 9

Steam reforming reactions of ethanol, biogas, and natural gas are introduced, Operating parameters of production process: temperatures, feed molar ratio, and conversion rates of reagents, Electrolysis process.

Unit – II: Thermodynamic analysis 9

Physicochemical analysis: Gibbs free energy, equilibrium constant, and degree of advancement. Renewable electrolytic processes: electrolyzer's efficiency, and the average efficiencies of wind, photovoltaic, and hydroelectric power plants.

Unit – III: Economic analysis 9

Costs of investment, operation, and maintenance of the system, resulting in the selection of option.

Unit – IV: Ecological Efficiency 9

Equivalent carbon dioxide processes: pollutant indicator (Π_g) and ecological efficiency (ε) of hydrogen production processes. Economical analysis of renewable energy sources: ethanol, biogas and green algae, carbon credit incorporation

Reference Books:

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

3. Bent Sorensen (Sorensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier Academic Press, UK
4. Kordesch, K and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany
5. Hart, A.B and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, New York Ltd., London
6. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA

List of Practical

1. Electrolysis of Water Using Alkaline Electrolyzer
2. PEM (Proton Exchange Membrane) Electrolyzer Operation
3. Effect of Electrolyte Concentration on Electrolysis Efficiency
4. Photocatalytic and Photoelectrochemical (PEC) Water Splitting
5. Hydrogen Production Using Algae (Biophotolysis)
6. Dark Fermentation of Organic Substrates for Biohydrogen
7. Biomass Gasification for Hydrogen Production
8. Hydrogen Purity Testing and Storage Methods

ECH-502: BIOHYDROGEN PRODUCTION

Course Category : Program Elective – V (PE-5)
Pre-requisite Subject : Nil
Contact hours/week : Lecture: 3, Tutorial:1, Practical: 0
No of Credits :
Course Assessment Methods Continuous assessment through tutorials, attendance, home assignments, quizzes, and one minor tests and One Major Theory Examination.
Course Objectives In the present course is useful for getting insides on biohydrogen production from the renewable sources. Details analysis of microbial selection, reactor selection, process parameters is included.
Course Outcome At the end of the course the students will be able to

1. Selection of microbial species for biohydrogen production
2. Selection of feedstock and operational parameters
3. Understand the process of dark fermentation
4. Operational parameters for dark fermentation
5. Understand concept of photobioreactor for fermentation
6. Cost analysis of process for biohydrogen production

Unit – I: Microbiology 9

Dark Fermentative Bacteria, Photosynthetic Fermentative Bacteria, Cyanobacteria, Green Algae, Concept of Consortia Development, Occurrence of Hydrogenase in Nature, Classification of Hydrogenases, Problems Associated with Oxygen Sensitivity of Hydrogenases and Plausible Solutions, Evolutionary Significance of Hydrgenase.

Unit – II: Biohydrogen Feedstock 9

Simple Sugars as Feedstock, Complex Substrates as Feedstock, Biomass Feedstock, Organic Acids, Waste as Feedstock, Assessment of Cost Components for Several Feedstocks for Dark Hydrogen Fermentation. Photobiological Hydrogen Production, Photofermentation, Dark Fermentation, Hybrid

Unit – III: Hydrogen Production Processes

Processes, Microbial Electrolysis Cell, Thermodynamic Limitations

Factors Affecting Dark Fermentation Process, Environmental Factors Affecting Hydrogen Production in Photosynthetic Organisms, Suspended Cell versus Immobilized Systems, Comparison of Batch Process versus Continuous Process.

Unit – IV: Photobioreactors 9

Types of PBRs, Physicochemical Parameters, Design Criterion, Comparison of the Performance of the PBRs,

Energy Analysis

Scale-Up Parameters, Scale-Up Methods, Case Studies on Pilot-Scale Plants, Mass and Energy Analysis, Cost Analysis of the Process

Reference Books:

1. 1. Debabrata Das, Namita Khanna, Chitralekha Nag Dasgupta (2014) Biohydrogen Production Fundamentals and Technology Advances, CRC press.
2. Prakash Kumar Sarangi, Krushna Prasad Shadangi, Pravakar Mohanty, Sanjukta Subudhi (2024) Biohydrogen Production: Recent Insights in Modeling, Storage, and Technology, CRC press
3. Ashok Pandey, Jo-Shu Chang, Patrick C. Hallenbeck, Christian Larroche (2013) Biohydrogen, Elsevier

ECH-702: HYDROGEN STORAGE AND TRANSPORT

Course Category : Program Elective – VI (PE-7)

Pre-requisite Subject : Nil

Contact hours/week : Lecture: 3, Tutorial:1, Practical: 0

No of Credits :

Course Assessment Methods Continuous assessment through tutorials, attendance, home assignments, quizzes, and one minor tests and One Major Theory Examination.

Course Objectives Course gives a brief overview of hydrogen storage and transportation, method for hydrogen transport and material selection. Safety considerations for hydrogen handling is covered

Course Outcome At the end of the course the students will be able to understand

1. Fundamental of hydrogen transportation and storage
2. Challenges and engineering properties of material for hydrogen storage
3. Material requirements for liquid hydrogen storage
4. Metal organic framework for hydrogen handling
5. Pipelines for hydrogen transportation and handling of cryogenic hydrogen
6. Safety considerations in hydrogen storage and transport

Unit - I: An Overview 9

Introduction to Hydrogen Storage, Transportation, and Distribution Technologies and Challenges, Engineering Properties of Hydrogen Storage Materials.

Unit – II: Storage 9

Liquid Hydrogen Carriers, Pressurized Gaseous Hydrogen Storage, Low-Temperature Liquefaction Hydrogen Storage, Carbonaceous Materials for Hydrogen Storage, Glass Microspheres for Hydrogen Storage, Metal-Organic Frameworks (MOF) for Hydrogen Storage.

Unit – III: Transportation

Pipelines for Hydrogen Transportation, Cryogenic Liquid Tankers for Hydrogen Transportation.

Unit-IV: Safety Consideration 9

Prevention of Hydrogen Pipeline Cracking and Leakage, Delayed Hydrogen Ignition and Explosion, Liquid Hydrogen Release from Pressurized and Non-pressurized Tanks.

Reference Books:

1. 1. Mohammad Reza Rahimpour, Mohammad Amin Makarem, Parvin Kiani (2024) Hydrogen Transportation and Storage, CRC press
2. Joerg Wellnitz, Agata Godula-Jopek, Walter Jehle (2023) Hydrogen Storage Technologies: New Materials, Transport, and Infrastructure, Wiley Interscience.

ECH-902: Cryogenic Hydrogen Technology

Course Category : Program Elective – IX (PE-9)

Pre-requisite Subject : Nil

Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 0
No of Credits	:
Course Assessment Methods	Continuous assessment through tutorials, attendance, home assignments, quizzes, and one minor tests and One Major Theory Examination.
Course Objectives	The course objective is to provide the fundamental concept of hydrogen and fuel cell and relevant engineering and technologies
Course Outcome	At the end of the course the students will be able to understand

1. Cryogenic hydrogen production,
2. Storage, transportation, and its end use.
3. The safety aspects of handling cryo-hydrogen
4. Thermodynamics of process
5. Necessary precautions will also be discussed
6. Gas handling and safety

Unit – I: Introduction of hydrogen technology 9

Energy Vector Applications, Advantages and Challenges Properties gaseous, liquid and slush hydrogen, Isotopes of hydrogen and their uses. Production of Synthesis gas (Steam Reforming, Partial Oxidation, Auto-thermal Reactor); Gasification of hydrogen, Hydrogen as fuel (in fuel cell); Hydrogen as fuel (for space application); Safety issues on hydrogen

Unit – II: thermodynamics of hydrogen technology 9

Processing of Synthesis gas (Linde-Bronn Process and l'Air Liquide System) Week 3: Thermodynamics of electrolytic hydrogen prodution H2 Production: electrolysis, tank & filter Press type electrolyser; PEM electrolysers; H2 Production: Thermo-chemical proces

Unit – III: Cryo-technology

Overview of cryogenic liquefaction cycles; maximum inversion temperature; overview of cryogenic liquefaction cycles; Problems, Liquefaction of hydrogen, Problems; ortho-para conversion of hydrogen; large scale hydrogen production process

Unit – IV Storage technology and handling 9

Different means of storing hydrogen – oerview; cryo-compressed gaseous hydrogen storage; metal hydride storage of hydrogen; Cryosorption storage of hydrogen in carbonaceous materials;

Liquefaction of hydrogen, Problems; ortho-para conversion of hydrogen; large scale hydrogen production process

Reference Books:

1. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA

Minor Degree 3: Advanced Materials Engineering

Category	Subject Code	Subject Title	Credit			Total Credit
			L	T	P	
PE-1	ECH-103	Advanced Polymeric Materials	3	1	0	4
PE-3	ECH-303	Advanced Methods of Materials Characterisation	3	0	2	4
PE-5	ECH-503	Advanced Composite Materials	3	0	2	4
PE-7	ECH-703	Energy Storage Materials	3	0	2	4
PE-9	ECH-903	Materials For Sustainable Engineering	3	1	0	4
					Total	**20**

ECH-103: ADVANCED POLYMERIC MATERIALS

Course Category : Programme Elective (PE-1)

Pre-requisite Subject : NIL

Contact hours/week : Lecture: 3, Tutorial:1, Practical: 0

No of Credits : 4

Course Assessment Methods : Continuous assessment through tutorials, attendance, home assignments, quizzes, and one minor tests and One Major Theory Examination.

Course Objectives : To impart the knowledge of

a. Newer polymers in wide applications
b. Basic concepts of various specialty polymers
c. Fundamentals as well as the recent developments in the field of polymeric materials.

Course Outcome : At the end of the course the students will be able to:

1. Explain the advanced concepts of polymer chemistry, including polymerization mechanisms and structure–property relationships.
2. Analyze the thermal, mechanical, and rheological behavior of advanced polymers to determine their suitability for specific engineering applications.
3. Evaluate the performance characteristics of specialty polymers such as conducting polymers, biodegradable polymers, and liquid crystal polymers.
4. Design polymer blends and composites with tailored properties for advanced applications in aerospace, biomedical, automotive, and electronics industries.
5. Interpret polymer characterization data obtained from techniques like FTIR, DSC, TGA, and SEM to understand material behavior.
6. Assess the environmental impact and sustainability of polymeric materials and propose strategies for recycling or biodegradation.

UNIT I: Specialty Polymers 9

High temperature and fire-resistant polymers, Liquid crystalline polymers, Dendrimers, Drag reduction, Polymer Cement, Ion-Exchange Resins and Anchored Catalysts, Photoactive Materials, Organometallic polymers, adhesives.

UNIT 2: Biopolymers 9

Polymeric bio-implants, Contact lenses, surgical sutures, artificial organs, drug delivery biopolymers, tissue Engineering.

UNIT 3: Polymers for Advanced Technologies 9

Conducting polymers, Membrane Science and Technology, Applications in Electronics and Energy, photonic Polymers, Sensor Applications.

UNIT 4: 9

Self-healing polymers, Polymer actuators, Shape memory polymers, Magneto rheological polymers, piezoelectric

polymers, Electroactive polymers.

References

1. S. Anandhan and S. Bandyopadhyay, Eds., Advances in Polymer Materials and Technology, 1st Edn, CRC Press, Boca Raton, 2016.
2. B.D. Ratner et al., Biomaterials Science: an Introduction to Materials in Medicine, 3rd Edn, Academic press, USA, 2012.
3. J. R. Fried, Polymer Science and Technology, 3rd Edn, Prentice Hall, USA, 2014.
4. M. Chanda, S. K. Roy, Industrial Polymers, Specialty Polymers, and their Applications, 1st Edn, CRC Press, USA, 2009.
5. J. Park &R.S. Lakes, Biomaterials: an Introduction, 3rd Edn, Springer, USA, 2007.
A. K. Bhowmick, Ed., Current Topics in Elastomers Research, CRC Press, USA. 2008.

ECH-303: ADVANCED METHODS OF MATERIALS CHARACTERISATION

Course Category : Programme Elective-III (PE-3)
Pre-requisite Subject : NIL
Contact hours/week : Lecture: 3, Tutorial:0, Practical: 2
No of Credits : 4
Course Assessment Methods : Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one minor test and One Major Theory & Practical Examination.
Course Objectives : To impart the knowledge of

a. Basic concepts of Materials Characterization.
b. Fundamentals of physicochemical characterisation of materials.
c. Basic principles, operating mechanism of various analytical techniques.
d. Applications of charactrization technologies.

Course Outcome : At the end of the course the students will be able to:

1. **Describe** the fundamental principles behind various advanced materials characterization techniques such as XRD, SEM, TEM, FTIR, AFM, and DSC.
2. **Explain** the operational principles, instrumentation, and applications of spectroscopic, microscopic, and thermal analysis methods in materials science.
3. **Apply** appropriate characterization techniques to analyze microstructure, composition, and thermal properties of various engineering materials.
4. **Analyze** data obtained from experimental methods to determine material characteristics such as crystallinity, phase composition, surface morphology, and elemental composition.
5. **Evaluate** the suitability of different techniques for specific materials characterization problems, considering accuracy, limitations, and resolution.
6. **Design** a systematic materials characterization plan for research or industrial applications using a combination of complementary techniques.

UNIT I: 9

X-ray diffraction: Principle, measuring system and applications for characterization of powdered materials. X-ray diffraction profile and analysis. Introduction to Extended X-ray absorption fine structure (EXAFS), Surface extended X-ray absorption (SEXAFS).

UNIT 2: 9

Microscopic techniques Principles, instrumentations and applications of Optical microscope, Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM) for characterization of different samples. Basic aspects of Energy dispersive X-ray microanalysis (EDS)

UNIT 3: 9

Spectroscopic methods Principle, instrumentation and applications of UV-Visible Diffuse Reflectance (UV-Vis DRS) spectroscopy, Ft-Ir, Raman and Fluorescence spectroscopy. Hand of experience on AAS, FT-IR, Raman and data analysis.

UNIT 4: 9

Thermo-analytical Methods Principle, instrumentation and applications of Thermogravimetric Analysis (TGA), Differential Temperature Analysis (DTA) and Differential Scanning Calorometry (DSC). Factors affecting the TGA/DTA/DSC results and their interpretations. Hand on on experience of operation of TG/DSC and data analysis.

List of experiments:

1. Determination of molecular weight by viscometer
2. Determination of K value of PVC
3. Electrochemical characterization of polymer.
4. Characterization by weight loss of common polymer by TGA
5. Characterization of thermal stability of common polymer by TGA
6. Determination of melting point range of common polymer by DSC
7. Determination of glass transition temperature of common polymer by DSC
8. Identification of polymer by IR spectroscopy

References

1) Theory and Applications of UV Spectroscopy, H.H.Jaffe and M.Orchin, IBH-Oxford.
2) Inorganic spectroscopic methods, A.K. Brisdon, Oxford Chem. Primers, 1997, New York.
3) Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L.Ho, Wiley Inter science. 4) Introduction to Spectroscopy, Pavia, Brooks/Cole Cenage, 4th edition, 2009, Belmont.
5) Introduction to Photoelectron Spectroscopy, P.K.Ghosh, John Wiley.
6) Fundamental of Molecular Spectroscopy, C. N. Banwell and E. McCash, Tata McGraw Hill, 4th edition, 1994, New Delhi.

ECH-503: ADVANCED COMPOSITE MATERIALS

Course Category	: Programme Elective -V (PE-5)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:0, Practical: 2
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one minor test and One Major Theory & Practical Examination.
Course Objectives	: To impart the knowledge of a. Basic concepts of knowledge of composites and its applications. b. Types and common manufacturing techniques of composites. c. Basic principles effect of operating parametersin selection of composites d. Necessary and relevant information including the state- of-the-materials
Course Outcome	: At the end of the course the students will be able to:

1. Explain and differentiate composite materials based on specific applications.
2. Explain the classification, types, and fundamental characteristics of composite materials and their matrix and reinforcement phases.
3. Describe the important fabrication methods based on matrix materials.
4. Narrate the various methods available to test the Composites through NDT methods.
5. Evaluate the effects of fiber orientation, volume fraction, and interface properties on the performance of composite laminates.
6. Analyze the mechanical behavior of fiber-reinforced composites under different loading conditions using micromechanics and macromechanics principles.

UNIT I: 9

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 2: 9

Polymer Matrix Composites-Thermoset Composite manufacturing- Lay- up processes, Sprayup process, Fiber placement process, Moulding process:Resin transfer, Vaccum assisted resin transfer, Compression moulding process, Filament winding. Thermoplastic Composite manufacturing- Sheet moulding, Blow moulding, rotational moulding Injection moulding, Calendaring, Extrusion, 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 3: COMPOSITES DESIGN AND TEST 9

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 4: POLYMER COMPOSITE MATERIALS: 9

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.

List of Experiments:

1. Manufacturing of composite by hand layup technique.
2. Manufacturing of composite by varying filler quality and quantity.
3. Study of chemical/water absorption behavior of polymers composites
4. Characterization of filler content /ash content of common polymer by TGA
5. Study of curing behavior of epoxy resin by DSC
6. Determination of gel time of a thermoset resin at a given temperature

References

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.
5. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
6. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

ECH-703: ENERGY STORAGE MATERIALS

Course Category : Programme Elective-VI (PE-7)

Pre-requisite Subject : NIL

Contact hours/week : Lecture: 3, Tutorial:0, Practical: 2

No of Credits : 4

Course Assessment Methods : Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one minor test and One Major Theory & Practical Examination.

Course Objectives : To impart the knowledge of

a) Emerging energy generation sources Types and common manufacturing techniques of composites.
b) Basic principles of storing and energy supply without any interruption
c) Necessary and relevant information regarding energy storage materials

Course Outcome : At the end of the course the students will be able to:

1. Understand and explain Need and scope of energy storage.
2. Describe the thermal energy and importance of thermal storage system.
3. Concept of chemical energy storage and challenges of chemical storage system.
4. Explain the purpose and significance of electromagnetic storage system.
5. Understand about various energy storage systems and their future perspective.
6. Compare different storage materials for their suitability in renewable energy integration and grid-level storage solutions.

UNIT I: INTRODUCTION: 9

Energy storage systems overview Scope of energy storage, needs and opportunities in energy storage, Technology overview and key disciplines, comparison of time scale of storages and applications, Energy storage in the power and transportation sectors. Importance of energy storage systems in electric vehicles, Current electric vehicle market.

UNIT 2: 9

Thermal storage system-heat pumps, hot water storage tank, solar thermal collector, application of phase change materials for heat storage-organic and inorganicmic and materials, efficiencies, and economic evaluation of thermal energy storage systems.

UNIT 3: 9

Chemical storage system- hydrogen, methane etc., concept of chemical storage of solar energy, application of chemical energy storage system, advantages and limitations
and limita of chemical energy storage, challenges, and future prospects of chemical storage systems

UNIT 4: 9

Electromagnetic storage systems - double layer capacitors with electrostatically charge storage, superconducting magnetic energy storage (SMES), concepts, advantages and limitations of electromagnetic energy storage systems, and future prospects of electrochemical storage systems.

References

1. Pistoia, Gianfranco, and Boryann Liaw. Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost. Springer International Publishing AG, 2018.
2. Robert A. Huggins, Energy storage, Springer Science & Business Media (2010)
3. Frank S. Barnes and Jonah G. Levine, Large Energy Storage Systems Handbook (Mechanical and Aerospace Engineering Series), CRC press (2011)

4. Ralph Zito, Energy storage: A new approach, Wiley (2010)

List of Practical

1. Synthesis of $LiFePO_4$ Cathode Material
2. Fabrication and Testing of a Coin Cell Battery
3. Electrochemical Impedance Spectroscopy (EIS) Analysis
4. Characterization of Electrode Materials using XRD
5. Specific Capacitance Measurement of Activated Carbon Electrode
6. Thermal Stability Analysis using TGA/DSC
7. Solid-State Electrolyte Preparation and Testing
8. Battery Safety and Abuse Testing

ECH-903: MATERIALS FOR SUSTAINABLE ENGINEERING

Course Category : Programme Elective-IX (PE-9)
Pre-requisite Subject : NIL
Contact hours/week : Lecture: 3, Tutorial:1, Practical: 0
No of Credits : 4
Course Assessment Methods : Continuous assessment through tutorials, attendance, home assignments, quizzes, and one minor tests and One Major Theory Examination.
Course Objectives : To impart the knowledge of

a. electrochemical energy and fuel cells.
b. Basic principles of batteries working
c. Necessary and relevant information regarding sustainable engineering materials

Course Outcome : At the end of the course the students will be able to:

1. Understand electrochemical energy storage and working principle of batteries.
2. Classify materials based on their life cycle, recyclability, and ecological footprint.
3. Explain the principles of sustainability and the role of material selection in minimizing environmental impact.
4. Evaluate the properties and applications of sustainable materials such as biodegradable polymers, recycled composites, and green concretes.
5. Apply life cycle assessment (LCA) techniques to compare environmental impacts of conventional and sustainable materials.
6. Design sustainable engineering solutions by selecting appropriate materials that align with energy efficiency and low carbon footprint goals.

UNIT I: 9

Electrochemical storage system: **Batteries**-Working principle of battery, primary and secondary (flow) batteries, battery performance evaluation methods, major battery chemistries and their voltages- Li-ion battery& Metal hydride battery vs lead-acid battery.

UNIT 2: 9

Supercapacitors- Working principle of supercapacitor, types of supercapacitors, cycling and performance characteristics, difference between battery and supercapacitors, Introduction to Hybrid electrochemical supercapacitors

UNIT 3: 9

Fuel cell: Operational principle of a fuel cell, types of fuel cells, hybrid fuel cell-battery systems, hybrid fuel cell-supercapacitor systems.

UNIT 4: 9

Battery design for transportation, Mechanical Design and Packaging of Battery Packs for Electric Vehicles, Advanced Battery-Assisted Quick Charger for Electric Vehicles, Charging Optimization Methods for Lithium-Ion Batteries, Thermal run-away for battery systems, Thermal management of battery systems, State of Charge and State of Health Estimation Over the Battery Lifespan, Recycling of Batteries from Electric Vehicles

References

1. Pistoia, Gianfranco, and Boryann Liaw. Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost. Springer International Publishing AG, 2018.
2. Robert A. Huggins, Energy storage, Springer Science & Business Media (2010)

Text books:

3. Frank S. Barnes and Jonah G. Levine, Large Energy Storage Systems Handbook (Mechanical and Aerospace Engineering Series), CRC press (2011)
4. Ralph Zito, Energy storage: A new approach, Wiley (2010)