Curriculum Structure & Syllabi

(As per National Education Policy 2020)

of

B. Tech.

in

Chemical Engineering

(w.e.f. 2024-25)

Vision, Mission, Program Educational Objectives
Program Outcomes, Program Specific Outcomes
Overall Credit Structure, Curriculum Syllabus

Offered By

DEPARTMENT OF CHEMICAL ENGINEEIRNG

MADAN MOHAN MALAVIYA UNIVERSITY OF TECHNOLOGY

GORAKHPUR-273 010, UP, INDIA

JULY 2024

VISION

To become a globally leading Chemical Engineering Department by imparting quality education through excellence in teaching, research and innovation.

MISSION

- to provide high-quality education that will prepare the students for leading roles in their professional journey.
- to contribute in the sustainable development of the nation and to improve the quality of life through education, research, professionalism and leadership.
- to work in collaboration with alumni and other technical institutes/universities/ industries/research organizations of national and international stature in order to address global challenges in the domain of Chemical Engineering.

PROGRAM EDUCATION OBJECTIVES

- to inculcate with knowledge of the fundamentals of Science and Engineering disciplines for developing the ability of students to formulate, solve and analyse the problems of Chemical Engineering.
- to assist the students in pursuit of their successful career by imparting them the lifelong skills of creative thinking and the ability to handle problems of practical relevance to society while complying with economic, environmental, ethical and safety factors.
- to impart the knowledge about contemporary technologies, practical experiences, and soft skills in multidisciplinary field for building up team spirit and leadership qualities by working on multidisciplinary projects.

PROGRAM SPECIFIC OUTCOMES

Graduate of Chemical Engineering of Department will able to

- demonstrate the Chemical Engineering fundamentals learnt through lectures, practicals, computer aided designs, projects, and field-based training.
- apply the knowledge of Chemical Engineering in addressing the needs of society including environmental stewardship and to identify, analyse, design and develop solution for complex engineering problems of practical relevance to chemical and allied industries.

PROGRAM OUTCOMES (PO)

PO1: ENGINEERING KNOWLEDGE: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in wk1 to wk4 respectively to develop to the solution of complex engineering problems.

PO2: PROBLEM ANALYSIS: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (wk1 to wk4)

PO3: DESIGN/DEVELOPMENT OF SOLUTIONS: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (wk5)

PO4: CONDUCT INVESTIGATIONS OF COMPLEX PROBLEMS: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (wk8).

PO5: ENGINEERING TOOL USAGE: create, select and apply appropriate techniques, resources and modern engineering & it tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (wk2 and wk6)

PO6: THE ENGINEER AND THE WORLD: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (wk1, wk5, and wk7).

PO7: ETHICS: apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (wk9)

PO8: INDIVIDUAL AND COLLABORATIVE TEAMWORK: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: COMMUNICATION: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences

PO10: PROJECT MANAGEMENT AND FINANCE: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11: LIFE-LONG LEARNING: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (wk8)

SYLLABUS AND CREDIT STRUCTURE FOR B. TECH. (CHEMICAL ENGG)
(SESSION 2024-2025 AND ONWARDS)
OVERALL CREDIT STRUCTURE FOR B.TECH. (CHEMICAL ENGG)

<table>
<tr><th colspan="4">Credit Courses</th></tr>
<tr><th colspan="2">Core Courses (CC)</th><th colspan="2">Electives Courses (EC)</th></tr>
<tr><th>Category</th><th>Min. Credits</th><th>Category</th><th>Min. Credits</th></tr>
<tr><td>Basic Sciences & Maths (BSM)</td><td>20</td><td rowspan="3">Professional Electives (PE)/ Open Electives (OE)</td><td rowspan="3">36</td></tr>
<tr><td>Engineering Fundamentals (EF)</td><td rowspan="2">24</td></tr>
<tr><td>Professional Skill (PS)</td></tr>
<tr><td>Professional Core (PC)</td><td>48</td><td>Humanities & Social Science Elective (HSSE)</td><td>04</td></tr>
<tr><td>Management (M)</td><td>04</td><td></td><td></td></tr>
<tr><td>Humanities & Social Science (HSS)</td><td>08</td><td></td><td></td></tr>
<tr><td>Minor Project (P)</td><td>06</td><td></td><td></td></tr>
<tr><td>Industrial Practice (IP) (In Industry)/ Major Project (MP) (In University)</td><td>10</td><td></td><td></td></tr>
<tr><td>Sub-total</td><td>120</td><td>Sub-total</td><td>40</td></tr>
<tr><td>Grand Total</td><td>160</td><td colspan="2"></td></tr>
<tr><th colspan="4">Non-Credit Courses</th></tr>
<tr><td colspan="3">One Expert Lecture per semester for students (Mandatory).
(BSM-Ist year), (PC-2nd Year), (T&P-3rd Year)</td><td>Non-Credit</td></tr>
<tr><td colspan="3">Social work/Training of at least 60 hours during break after first/ second semester (Mandatory) (Dean of Extension, Field Outreach and Alumni Relations).</td><td>Non-Credit</td></tr>
<tr><td colspan="3">Industrial Training during the summer break after fourth semester (Mandatory).</td><td>Non-Credit</td></tr>
<tr><td colspan="3">One -week workshop during the winter break after fifth semester on professional/ industry/ Social/ entrepreneurial orientation (Mandatory) (Dean of Extension, Field Outreach and Alumni Relations).</td><td>Non-Credit</td></tr>
<tr><td colspan="3">Value Added Courses (VAC) / Audit Courses (AC)
Two of the Value-Added Courses / Audit Courses are compulsory.</td><td>Non-Credit</td></tr>
<tr><td colspan="3">Extracurricular Activities Courses (ECA)
Two compulsory courses from the following S. No (ii) to (v) non-credit courses:
(i) Induction Program (compulsory)
(ii) Skill development
(iii) Unity and Discipline (NCC or NSS)
(iv) Sports, Cultural and Games
(v) Personality Development</td><td>Non-Credit</td></tr>
<tr><td colspan="4">Minor Degree (MD) from any Department and Micro Specializations (MS) within the Department</td></tr>
<tr><td colspan="3">• The total number of credits for graduation will be kept to minimum 160 excluding the 18-20 credits required for Minor Degree Courses.</td><td>Offered as a Professional Electives (PE)</td></tr>
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DEPARTMENT OF CHEMICAL ENGINEERING
MADAN MOHAN MALAVIYA UNIVERSITY OF TECHNOLOGY (MMMUT)
GORAKHPUR-273 010, UP, INDIA

SEMESTER WISE CREDIT STRUCTURE FOR B. TECH. CHEMICAL ENGINEERING

Category/Semesters	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**Total**
Basic Sciences & Maths (BSM)	8	8	0/4	4/0					**20***
Humanities & Social Science (HSS)	4	4							**08***
Humanities & Social Science Elective (HSSE)					4				**04***
Management (M)						4			**04***
Engineering Fundamentals (EF)	4	4	8/4	0/4					**16***
Professional Skill (PS)	4	4							**08***
Professional Core (PC)			12	12	12	12			**48***
Professional Electives (PE)/ Open Electives (OE)				4-8	28-32				**36***
Minor Project (P)						0	6		**06***
Industrial Practice (IP) (in Industry)/ Major Project (MP) (In University)								10	**10***
Total Credit	**20***	**20***	**20***	**20-24***	**16*-32***	**16*-32***	**6-30***	**10-30***	**160***
	80-84*				**76-80***				
Total Courses Offered	**05***	**05***	**05***	**05*-06***	**04*-08***	**04*-08***	**00-06***	**00-05***	**36***

**Minor variation is allowed as per need of the respective disciplines.*

First Year, Semester I

S. N.	**Category**	**Paper Code**	**Subject**	**L**	**T**	**P**	**Credit**
1.	BSM	BSM-110	Engineering Mathematics -I	3	1	0	4
2.	BSM	BSM-131	Engineering Physics	3	0	2	4
3.	EF	BIT-101	Programming in C	3	0	2	4
4.	PS	BME-101	Manufacturing Techniques Workshop	2	0	4	4
5.	HSS	BHS-101	Universal Human Values	3	1	0	4
			Total	**14**	**2**	**8**	**20**
6.	ECA-I		Induction Program	-	-	-	0

 # Group-1: CSE, IT, CH, CE; Group-2: ECE, ECE(IOT), ME, EE.

First Year, Semester II

S. N.	Category	Paper Code	Subject	L	T	P	Credit
1.	BSM	BSM-160	Engineering Mathematics - II	3	1	0	4
2.	BSM	BSM-190	Environmental Science and Green Chemistry	3	0	2	4
3.	EF	BEE-157	Basics of Electrical Engineering	3	0	2	4
4.	PS	BME-157	Engineering Graphics with AutoCAD	2	0	4	4
5.	HSS	BHS-152	Technical Writing and Professional communication	3	0	2	4
			Total	**14**	**1**	**10**	**20**
6.	VAC/AC	BCH-124	Creativity for Chemical Engineers	0	0	2	0
7.	ECA-II			-	-	-	**0**

Second Year, Semester III

S. N.	Category	Paper Code	Subject	L	T	P	Credit
1.	BSM	BPT-085	Biology for Chemical Engineers	3	0	2	4
2.	EF	BCH-205	Chemical Engineering Thermodynamics -I	3	1	0	4
3.	PC	BCH-206	Process Calculation	3	1	0	4
4.	PC	BCH-207	Fluid Flow Operation	3	0	2	4
5.	PC	BCH-208	Particulate Technology	3	0	2	4
			Total	**15**	**2**	**6**	**20**
6.	VAC/AC	AUC-101	Constitution of India	2	0	0	0
7.	AC	AUC-119	Basics of Artificial Intelligence	2	0	0	0
7.	ECA-III			-	-	-	0

Second Year, Semester IV

S. N.	Category	Paper Code	Subject	L	T	P	Credit
1.	EF	BCH-257	Chemical Engineering Thermodynamics - II	3	0	2	4
2.	PC	BCH-258	Heat Transfer Operation	3	0	2	4
3.	PC	BCH-259	Reaction Engineering – I	3	0	2	4
4.	PC	BCH-260	Mass Transfer – I	3	0	2	4
	Student may choose either PE-1 or PE-2 or Both PE-1 and PE-2.						
5.	PE		PE-1*	3	1/0	0/2	4
6.	PE		PE-2	3	1/0	0/2	4
			Total	**15**	**0-2**	**8-12**	**20-24**
7.	VAC/AC	AUC-104	Indian Festivals	2	0	**0**	0

8.	ECA-IV			-	-	-	0

Third Year, Semester V

S. N.	Category	Paper Code	Subject	L	T	P	Credit
1.	PC	BCH-305	Chemical Technology	3	0	2	4
2.	PC	BCH-306	Reaction Engineering – II	3	0	2	4
3.	PC	BCH-307	Mass Transfer – II	3	0	2	4
4.	HSSE	BHS-303	Industrial/Organizational Psychology	3	1	0	4
	Student may choose maximum up to 04 courses from the list of PE category courses (PE-1 to PE-9).						
5.	PE		PE-1	3	1/0	0/2	4
6.	PE		PE-2	3	1/0	0/2	4
7.	PE		PE-3	3	1/0	0/2	4
8.	PE		PE-4	3	1/0	0/2	4
9.	PE		PE-5	3	1/0	0/2	4
10.	PE		PE-6	3	1/0	0/2	4
11.	PE		PE-7	3	1/0	0/2	4
12.	PE		PE-8	3	1/0	0/2	4
13.	PE		PE-9	3	1/0	0/2	4
			Total	**12-24**	**1-8**	**6-16**	**16-32**
14.	ECA-V			-	-	-	0

Third Year, Semester VI

S. N.	Category	Paper Code	Subject	L	T	P	Credit
1.	PC	BCH-354	Process Equipment Design	3	0	2	4
2.	PC	BCH-355	Transport Phenomena	3	1	0	4
3.	PC	BCH-356	Process Control & Instrumentation	3	0	2	4
4.	M	BMS-352	Engineering Economics and Financial Management	3	1	0	4
5.	P	BCH-371	Minor Project-1	0	0	0	0
	Student may choose maximum up to 04 courses from the list of PE category courses (PE-1 to PE-9).						
6.	PE		PE-1	3	1/0	0/2	4
7.	PE		PE-2	3	1/0	0/2	4
8.	PE		PE-3	3	1/0	0/2	4
9.	PE		PE-4	3	1/0	0/2	4
10.	PE		PE-5	3	1/0	0/2	4
11.	PE		PE-6	3	1/0	0/2	4
12.	PE		PE-7	3	1/0	0/2	4

13.	PE		PE-8	3	1/0	0/2	4
14.	PE		PE-9	3	1/0	0/2	4
			Total	**12-24**	**1-8**	**0-16**	**16-32**
15.	ECA-VI			-	-	-	0

Final Year, Semester VII

S. N.	Category	Paper Code	Subject	L	T	P	Credit
1.	P	BCH-441	Minor Project-2	0	0	12	6
	Student may choose maximum up to 06 courses from the list of PE category courses (PE-3 to PE-9).						
2.	PE		PE-1	3	1/0	0/2	4
3.	PE		PE-2	3	1/0	0/2	4
4.	PE		PE-3	3	1/0	0/2	4
5.	PE		PE-4	3	1/0	0/2	4
6.	PE		PE-5	3	1/0	0/2	4
7.	PE		PE-6	3	1/0	0/2	4
8.	PE		PE-7	3	1/0	0/2	4
9.	PE		PE-8	3	1/0	0/2	4
10.	PE		PE-9	3	1/0	0/2	4
			Total	**0-18**	**0-6**	**12-30**	**6-30**
11.	ECA-VII			-	-	-	0

Final Year, Semester VIII

S. N.	Category	Paper Code	Subject	L	T	P	Credit
1.	IP	ICH-401	Industrial Practice (IP)	0	0	20	10
Without Industrial Practice (IP)							
2.	MP	ICH-481	Major Project (MP)	0	0	20	10
	Student may choose maximum up to 05 courses from the list of PE category courses (PE-3 to PE-9).						
3.	PE		PE-1	3	1/0	0/2	4
4.	PE		PE-2	3	1/0	0/2	4
5.	PE		PE-3	3	1/0	0/2	4
6.	PE		PE-4	3	1/0	0/2	4
7.	PE		PE-5	3	1/0	0/2	4
8.	PE		PE-6	3	1/0	0/2	4
9.	PE		PE-7	3	1/0	0/2	4
10.	PE		PE-8	3	1/0	0/2	4
11.	PE		PE-9	3	1/0	0/2	4
			Total	**0-15**	**0-5**	**20-30**	**10-30**

List of Professional Electives

Category	Paper Course	Course	L	T	P	Credit
Food Processing Technology						
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
Green Hydrogen Technology						
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
Advanced Materials Engineering						
PE-1	ECH-103	Advanced Polymeric Materials	3	1	0	4
PE-3	ECH-303	Advanced Methods of Materials Characterization	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
Process Design and Safety						
PE-2	ECH-201	Chemical Equipment Design	3	0	1	4
PE-4	ECH-401	Principles of Safety Management	3	1	0	4
PE-6	ECH-601	Chemical Process Safety	3	1	0	4
PE-8	ECH-801	Fire Engineering Fundamentals	3	1	0	4
Machine Learning for Chemical Engineers						
PE-2	ECH-202	Basics of Machine Learning for Chemical Engineering	3	0	2	4
PE-4	ECH-402	Artificial Neural Networks and Deep Learning	3	0	2	4
PE-6	ECH-602	Programming Basics of Machine Learning	3	0	2	4
PE-8	ECH-802	Computational Techniques for Machine Learning	3	1	0	4
Novel Separation Processes						
PE-2	ECH-203	Reactive Separation Techniques	3	0	2	4
PE-4	ECH-403	Introduction to Membrane Separation Processes	3	1	0	4
PE-6	ECH-604	Desalination and Cleaner Water Production with Membrane Technologies	3	0	2	4
PE-8	ECH-805	Interfacial Engineering	3	1	0	4

List of Value-Added Courses (VAC)/Audit Courses (AC)

S.No.	Subjects	Codes
1.	Constitution of India	AUC101
2.	Indian Culture and Heritage	AUC102
3.	Indian Architecture	AUC103
4.	Indian Festivals	AUC104
5.	Vedic Mathematics	AUC105
6.	Astronomy	AUC106
7.	Arts of India	AUC107
8.	Intellectual Property Rights	AUC108
9.	Human Rights	AUC109
10.	Logical Research	AUC110
11.	Professional Ethics	AUC111
12.	Environmental Law	AUC112
13.	Health Law	AUC113
14.	National Cadet Corps	AUC114
15.	Basics of Human Health and Preventive Medicines	AUC115
16.	Constitution Of India And Environmental Governance: Administration And Adjudication	AUC116
17.	Directive Principles Of State Policy And Fundamental Duties: Constitutional Imperative	AUC117
18.	Introduction To Intellectual Property To Engineers And Technologists	AUC118
19.	Fundamentals of Artificial Intelligence	AUC119
20.	Indian Knowledge Through Classical Languages	IKS101
21.	Indian Knowledge System: Concepts And Applications In Science	IKS102
22.	Indian Knowledge System: Concepts And Applications In Engineering	IKS103
23.	Indian Knowledge System	IKS104

**Note: Detailed syllabus of Audit Courses (AC) is attached as Annexure-02.

List of Extra Curricular Activity (ECA) Courses

ECA-II						
S. No.	Branch	Category	Subject Name	Subject Code	Hours/ Week	Credit
1.	Open to all Branches	ECA	Skill Development-I	ECA-151	2	0
2.	Open to all Branches	ECA	Unity and Discipline (NCC)-I	ECA-171	2	0
3.	Open to all Branches	ECA	Unity and Discipline (NSS)-I	ECA-172	2	0
4.	Open to all Branches	ECA	Games & Sports-I	ECA-181	2	0

5.	Open to all Branches	ECA	Cultural, Art & Literary-I	ECA-182	2	0

ECA-III						
S. No.	Branch	Category	Subject Name	Subject Code	Hours/ Week	Credit
1.	Open to all Branches	ECA	Skill Development-II	ECA-201	2	0
2.	Open to all Branches	ECA	Unity and Discipline (NCC)- II	ECA-221	2	0
3.	Open to all Branches	ECA	Unity and Discipline (NSS)-II	ECA-222	2	0
4.	Open to all Branches	ECA	Games & Sports-II	ECA-231	2	0
5.	Open to all Branches	ECA	Cultural, Art & Literary-II	ECA-232	2	0

ECA-IV						
S. No.	Branch	Category	Subject Name	Subject Code	Hours /Week	Credit
1.	Open to all Branches	ECA	Skill Development-III	ECA-251	2	0
2.	Open to all Branches	ECA	Unity and Discipline (NCC)- III	ECA-271	2	0
3.	Open to all Branches	ECA	Unity and Discipline (NSS)- III	ECA-272	2	0
4.	Open to all Branches	ECA	Games & Sports-III	ECA-281	2	0
5.	Open to all Branches	ECA	Cultural, Art & Literary-III	ECA-282	2	0

ECA-V						
S. No.	Branch	Category	Subject Name	Subject Code	Hours/Week	Credit
1.	Open to all Branches	ECA	Skill Development-IV	ECA-301	2	0
2.	Open to all Branches	ECA	Unity and Discipline (NCC)- IV	ECA-321	2	0
3.	Open to all Branches	ECA	Unity and Discipline (NSS)-IV	ECA-322	2	0
4.	Open to all	ECA	Games & Sports-IV	ECA-331	2	0

	Branches					
5.	Open to all Branches	ECA	Cultural, Art & Literary-IV	ECA-332	2	0

ECA-VI						
S. No.	Branch	Category	Subject Name	Subject Code	Hours/ Week	Credit
1.	Open to all Branches	ECA	Skill Development-V	ECA-351	2	0
2.	Open to all Branches	ECA	Games & Sports-V	ECA-381	2	0
3.	Open to all Branches	ECA	Cultural, Art & Literary-V	ECA-382	2	0

ECA-VII						
S. No.	Branch	Category	Subject Name	Subject Code	Hours/ Week	Credit
1.	Open to all Branches	ECA	Skill Development-VI	ECA-401	2	0
2.	Open to all Branches	ECA	Games & Sports-VI	ECA-431	2	0
3.	Open to all Branches	ECA	Cultural, Art & Literary-VI	ECA-432	2	0

**Note: Detailed syllabus of Extra Curricular Activity (ECA) Courses is attached as Annexure-03.

MMMUT Multiple Entry- Multiple Exit (ME-ME) Policy for Undergraduate (B.Tech.) #

Academic Level	ENTRY QUALIFICATION $	EXIT QUALIFICATION AND CREDITS required for the level	NATIONAL CREDIT LEVEL (NCrF)
UNDER-GRADUATE 1 st year (B.Tech.)	**Class 12 or equivalent** at National Credit Level 4.0	**UG Certificate (Engg.)** Minimum 40 credit-hours followed by an exit 4 to 6 credits skills-enhancement course at National Credit Level 4.5.	**4.5**
UNDER-GRADUATE 2nd year (B.Tech.)	**UG Certificate (Engg.) or 3 Year Diploma** at National Credit Level 4.5	**UG Diploma (Engg.)** Minimum of 80 credit-hours followed by an exit 4 to 6 credits skills-enhancement course at National Credit Level 5.0	**5.0**
UNDER-GRADUATE	**UG Diploma (Engg.)** at National Credit Level 5.0 with	**B. Voc. (Engg.)** Minimum of 120 credit-hours followed by an exit 4 to 6 credits	**5.5**

3 rd year (B.Tech.)	minimum 75 % marks or equivalent	skills-enhancement course at National Credit Level 5.5	
GRADUATE 4 th year (B.Tech.)	**B. Voc. (Engg.)** at National Credit Level 5.5 with minimum 75 % marks or equivalent	**B.Tech. (Engg.)** Must Complete at least 160 Credits. At National Credit Level 6.0	**6.0**

As per Multiple Entry Multiple Exit options by UGC & AICTE given in National Credit Framework (NCrF) 2023.

$ At each entry, University has to identify the educational gaps/ skill gaps and suitable bridge courses may be offered.

BSM-110	**Engineering Mathematics I**	
Course category	:	Basic Sciences & Maths (BSM)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and One Minor test and One Major Theory Examination
Course Objectives	:	The course is aimed at developing the basic mathematical skills of engineering students that are imperative for effective understanding of engineering subjects.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course 1. Use of basic differential operators in various engineering problems. 2. Understand the concepts of limit theory and nth order differential equations and their applications to our daily life 3. Solve linear system of equations using matrix algebra. 4. Know about qualitative applications of Gauss, Stoke's and Green's theorem. 5. To know the applications of double and triple integration in finding the area and volume. 6. To inculcate the habit of mathematical thinking and lifelong learning.

Topics Covered	
UNIT-I: Differential Calculus	9
Limit, Continuity and Differentiability, Mean value theorems. Leibnitz theorem, Partial derivatives, Euler's theorem for homogenous function, Total derivative, Change of variable. Taylor's and Maclaurin's theorem. Expansion of function of two variables, Jacobian, Extrema of function of several variables.	
UNIT-II: Linear Algebra	9
Symmetric, Skew-symmetric matrices, Hermitian, Skew Hermitian Matrices, orthogonal and unitary matrices and basic properties, linear independence and dependence of vectors, Rank of Matrix, Inverse of a Matrix, Elementary transformation, Consistency of linear system of equations and their solution, Characteristic equation, Eigenvalues, Eigen-vectors, Cayley-Hamilton theorem, Diagonalization of matrices.	
UNIT-III: Multiple Integrals	9
Double and triple integrals, change of order of integration, change of variables. Application of multiple integral to surface area and volume. Beta and Gamma functions, Dirichlet integral.	
UNIT-IV: Vector Calculus	9
Gradient, Divergence and Curl. Directional derivatives, line, surface and volume integrals. Applications of Green's, Stoke's and Gauss divergence theorems (without Proofs).	

Books & References

1. B.S. Grewal: Higher Engineering Mathematics; Khanna Publishers
2. Erwin kreyszig: Advanced Engineering Mathematics, John Wiley & Sons.
3. R. K. Jain and Iyenger: Advanced Engineering Mathematics, Narosa Publications.
4. B.V. Ramana: Higher Engineering Mathematics, Tata Mc. Graw Hill Education Pvt. Ltd.,

BSM 131/181		**ENGINEERING PHYSICS**
Course category	:	Basic Sciences and Maths (BSM)
Pre-requisite Subject	:	Physics at 12thStandard
Contact hours/week	:	Lecture: 3, Tutorial: 0 , Practical: 2
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Objectives	:	Understanding of the principles and concept of Optics, Quantum Mechanics, Fiber Optics, Electrodynamics and Physics of Advanced Materials.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills, and attributes after completing this course. 1. Understand the basics principles of Optics and its applications in Engineering and Technology. 2. Compare and understand the uses of various applications of interference and diffraction in the different fields of Engineering. 3. Know the knowledge of polarization and their applications in Photonics. 4. Understand the principles of Quantum Mechanics and their applications in Engineering and Technology. 5. Know the principles of Electrodynamics and their applications in Engineering and Technology. 6. Understand the basic properties of advanced materials and their engineering applications.

Topics Covered

UNIT-I: Optics	**9**

Interference: Interference of light, Interference in thin films, Newton's rings. Refractive index and wavelength determination.

Diffraction: Fresnel and Fraunhofer class of diffraction. Resultant of n-hormonic waves, single, double and N- slit diffraction, Diffraction grating, Grating spectra, Dispersive power.

Polarization: Phenomena of double refraction, Nicol prism, Production and analysis of plane, circular and elliptical polarized light, Retardation Plate, Polarimeter.

UNIT – II: Quantum Mechanics	**9**

Quantum Mechanics: de Broglie waves, Davisson-Germer experiment, Concept of Phase and Group velocities, Uncertainty principle and its applications, Derivation of time independent and time dependent Schrodinger wave equations. Postulates of quantum mechanics, Significance of

wave function, Application of Schrodinger wave equation for a particle in one dimensional infinite potential well.

UNIT-III: Electrodynamics	**9**

Scalar and Vector fields, Gradient, Divergence and curl, Concept of displacement current, Maxwell's equation in differential and integral forms, Physical significance of each equation.

Maxwell's equation in free space, Velocity of electromagnetic wave, Transverse nature of the electromagnetic wave, Poynting vector, Maxwell's equations in dielectric and conducting medium, and skin depth.

UNIT-IV: Physics of Advanced Materials	**9**

Concept of energy bands in solids, Semiconducting materials, Concept of direct and indirect band gap in semiconductors, Carrier concentration and conductivity in semiconductors, Optoelectronic Materials, Superconducting Materials, Temperature dependence of resistivity in superconducting materials, Effect of magnetic field (Meissner effect), Type I and Type II superconductors, London Equations, BCS theory (Qualitative), Introduction of nanoscience, Nanotechnology and its applications.

EXPERIMENTS

1. To determine the specific resistance of a given wire using Carrey Foster's Bridge.
2. To determine the wavelength of sodium light using Newton's Ring experiment.
3. To determine the wavelength of spectral lines of white light using plane diffraction grating.
4. To determine the specific rotation of cane sugar solution using polarimeter.
5. To study the variation of magnetic field along the axis of current carrying circular coil.
6. To study the Hall's effect and to determine Hall coefficient in n type Germanium.
7. To study the energy band gap of Germanium using four probe method.
8. To determine the height of Tower by Sextant.

Books & References

1. Optics- Ajoy Ghatak, Tata McGraw-Hill
2. Optics- N. Subrahmanyam, Brij Lal, M.N. Avadhanulu, S. Chand
3. Quantum Mechanics: Theory and Applications- Ajoy Ghatak, Tata McGraw-Hill
4. Fiber optics and laser Principles and Applications-Anuradha De, New Age International
5. Optical Fibers and its application as sensors by R. K. Shukla, New Age International.
6. Introduction to Electrodynamics by David J. Griffiths, Pearson
7. Physics of Semiconductor Devices, by S. M. Sze, Wiley
8. Concepts of Modern Physics by Arthur Beiser, Tata MCGraw Hill.
9. Introduction to Solid State Physics by C. Kittel, Wiley.
10. Engineering Physics by B. K. Pandey and S. Chaturvedi, 3e Cengage Learning Pvt. Limited, India.
11. Engineering Physics by H. K. Malik and A. Singh Tata MCGraw Hill.
12. Advanced Practical Physics Vol. I and Vol. II by D. K. Dwivedi, Victorius Publishers, New Delhi.

BIT-101	PROGRAMMING IN C	
Course category	:	Engineering Fundamentals (EF)
Pre-requisite Subject	:	-
Contact hours/week	:	Lecture: 3, Tutorial: 0, Practical:2
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce, Minor test and Major Theory Examination
Course Objectives	:	Students will gain an understanding of the fundamentals of computers and programming. The objective is to prepare them for various dimensions of C Programming language.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course 1. Describing the basics of terminologies used in computer programming. 2. Practicing C language programming by writing, compiling and debugging the code. 3. Designing programs involving simple statements, conditional statements, iterative statements, array, strings, functions, recursion and structure. 4. Discussing the dynamic memory allocations and use of the pointers. 5. Applying basic operations on files through programs. 6. Studying and implementing the codes using macros, pre-processor directives and command line arguments

Topics Covered	
UNIT-I: **Basics of Computers and Programming**	9
Functional diagram of computer; Language Processors; Approaches to problem solving, Concept of algorithm and flow charts. **Simple Statements:** Data types; Tokens and its types; Variable declaration and initialization; User defined type declaration: type def, enum; Comments; Format specifiers; Standard I/O: taking input and displaying output; **Operators:** types, precedence and associativity; Expressions; Type conversion, Cshort-hands.	
UNIT-II: Conditional Statements	9
Simple if, if-else, nested if-else, else-if ladder, switch statements, nested switch, advantages of switch over nested if, restrictions on switch values. **Iterative Statements:** Concepts of entry and exit controlled loops; Uses of for, while and do while loops; Nested Loops; Printing various patterns using nested loops; Using break, continue and goto statements.	
UNIT-III: Arrays	9
Single-dimensional, multi-dimensional array and their applications; declaration and manipulation of arrays; strings and string handling functions. **Pointers:** Pointer and address arithmetic; dereferencing; pointers and arrays; dynamic memory allocation and de-allocation. **Functions:** Function prototype; Arguments and its types: actual, formal and default arguments; Scope of a variable; Argument passing methods; Passing pointer as the function argument; Recursion: types, advantages and disadvantages; Storage class specifies; Character test functions.	

UNIT-IV: Structure	9
Declaring and defining structures; Array within structure; Array of structure; Defining and using some data structures: Stack, Queue, and Linked lists. **File Handling:** Types of files; Text files and different operations on text files, opening a file, closing a file; Data structure of a file; EOF; I/O operations on files; Random access to the files. **Standard C Pre-processors & C Library:** Pre-processor, Directives, Macro, Macro substitution; Conditional Compilation; Command Line Arguments; Standard C Library.	

List of experiments

1. To determine the specific resistance of a given wire using Carrey Foster's Bridge.
2. To determine the wavelength of sodium light using Newton's Ring experiment.
3. To determine the wavelength of spectral lines of white light using plane diffraction grating.
4. To determine the specific rotation of cane sugar solution using polarimeter.
5. To study the variation of magnetic field along the axis of current carrying circular coil.
6. To study the Hall's effect and to determine Hall coefficient in n type Germanium.
7. To study the energy band gap of Germanium using four probe method.
8. To determine the height of Tower by Sextant.

Textbooks

1. Brian W. Kernighan and Dennis M. Ritchie, "The C programming language", Pearson
2. E. Balagurusamy, "Programming in ANSI C", McGraw Hill Education
3. Yashavant Kanetkar, "Let Us C", bpb publication
4. Jeri R. Hanly, Elliot B. Koffman, "Problem Solving and Program Design in C", Pearson
5. Herbert Schildt,"C: The Complete Reference", McGraw Hill Education

BME 101/BME 151	**Manufacturing Practice Workshop**	
Course Category	:	Professional Skill (PS)
Pre-requisite Subject	:	NIL
Contact Hours/Week	:	Lecture: 2, Tutorial: 0, Practical: 04
Number of Credits	:	04
Course Assessment Method	:	Continuous assessment through one viva-voice, Practical, work/ record, attendance, and Major Practical Examination
Course Objective		This course introduces basic concepts of various manufacturing processes and their applications in production of complex shape andsize products based on the concepts of forming, welding, casting and machining.
Course Outcomes	:	After completion of this course the students are expected to be able to demonstrate the following knowledge, skills, and attitudes 1. Understand the importance of materials, applications, and safety in different shops for the development of a product/component. 2. The knowledge of tools and processes used in carpentry and foundry shops for the developmentof products through the casting process. 3. The knowledge of forming process will develop skills for producing products using differenttools and processes in the black smithy and sheet metal shops.

		4. The knowledge and practical skill of various welding processes and their application. 5. The knowledge and practical skill of various machining processes. 6. Knowledge of non-conventional machining will develop the ability to produce variousproducts.
Topics Covered (Make at least one job in each shop):		
Unit I		6
Concept of Manufacturing- Manufacturing definition; Role of materials, processes and systems in manufacturing; Classification and brief introduction of engineering materials such as metals & alloys, Classification and brief introduction of manufacturing processes.		
Unit II		**6**
Sand Casting Process of Metals- Elements of Green Sand Mould; Pattern design and making, Method of Preparation of Green Sand Mould; Casting Defects		
Unit III		**6**
Metalworking Processes- Classification of Metalworking Processes-brief introduction of bulk and sheet metal processes, Hot Vs Cold Working; Hot and Cold Rolling; Types of Rolling Mills, Forging, Extrusion, Drawing **Fabrication Processes-** Classification of Welding Operations, Types of Joints & Welding Positions; Brief description of Arc, Resistance and Gas welding techniques. Brazing and Soldering		
Unit IV		6
Machining Processes: Classification of machining processes & machine tools; Construction, Specification, and operations on Lathe Machine and Drilling machine		
List of experiments 1. **Safety in Workshop (Demonstration)** Safety precautions and utilization of hand tools and machines of different shops with safe working habits. Introduction to measuring equipments and gauges of different shops. 2. **Carpentry** Study of wood works, types of hand tools and machine. Making of one job involving wood work joint 3. **Fitting** Study of different fits and hand tools. Making of one job involving fitting to size, malefemale fitting with drilling and tapping 4. **Welding** Study of electric arc welding and gas welding, tools, types of weld joints and safety precaution during welding. Making of one joint using electric and gas welding. Students will be introduced to brazing and soldering (demonstration) 5. **Sheet Metal Work** Study of different hand tools, machine and sheet metal joints. Making of one utility job in sheet metal 6. **Foundry** Principles of molding, methods, core & core boxes, preparation of sand mould of given pattern and casting (demonstration) 7. **Black Smithy**		

Introduction to hot working and Study of forging hand tools, furnace and machine. Making a job on hot upset forging.

8. **Machining**

Study of lathe machine, cutting tools and turning related operations. Making of one job on lathe machines include facing, step and taper turning, threading operations.

9. **Plastic Processing**

Introduction to plastics and different plastic molding techniques. Study of injection molding process with demonstration.

10. **Computer Numerical Control (CNC)**

Introduction to automation & CNC, Assembly of models of CNC, CNC wood router, engraving and exposure to part programming. Preparation of part program for simple profiles.
Making a job on CNC (Demonstration).

11. **Mini Project**

Team activity – Fabrication of prototype model based on above practical.

Text and Reference Books

1. Manufacturing Science: A. Ghosh and A.K. Mallik (East- West Press).
2. Workshop Technology Vol-I: B. S. Raghuvanshi (Dhanpat Rai and Sons)
3. Workshop Technology Vol-II: B. S. Raghubanshi (Dhanpat Rai and Sons)

BHS- 101/151		**Universal Human Values: Understanding Harmony**
Course category	:	HSS
Pre-requisite Subject	:	None
Contact hours/week	:	4
Number of Credits	:	Lectures: 3, Tutorial: 1, Practical: 0
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Objectives	:	The objectives of this course are to: - 1. Develop a holistic perspective in students based on self-exploration about themselves (human being), family, society and nature/existence. 2. Develop understanding (or developing clarity) in students about harmony in the human being, family, society and nature/existence. 3. Strengthen self-reflection in students. 4. Develop commitment and courage in students to act.

Course Outcomes	:	The students will be able to demonstrate the following knowledge, skills, and attitudes upon completion of the course: - 1. Ability to understand the interconnectedness of humanity and nature as well as the importance of values in interpersonal relationships. 2. Ability to recognize their role as global citizens and understand the importance of actively contributing to the betterment of society through responsible actions. 3. Ability to engage in critical reflection on their own values and beliefs, challenging assumptions and biases to foster personal growth and development. 4. Ability to appreciate and respect diversity thereby promoting communication and conflict resolution skills, promoting dialogue and understanding in resolving interpersonal and intergroup conflicts.

Topics Covered	
Unit – I: Introduction to Values	9
Origin, definition, meaning, and types of values; Values in Education System; difference between Values, Morals, and Ethics; Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and 'Experiential Validation' as the process for self-exploration; Continuous Happiness and Prosperity- A look at basic human aspirations; Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority; Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario; Method to fulfil the above human aspirations: understanding and living in harmony at various levels.	
Unit – II	9
Understanding human being as a co-existence of the sentient 'I' and the material 'Body'; Understanding the needs of Self ('I') and 'Body' - happiness and physical facility; Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer); Understanding the characteristics and activities of 'I' and harmony in 'I'; Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail; Programs to ensure Sanyam and Health.	
Unit – III	9
Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship; Understanding the meaning of Trust; Difference between intention and competence; Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship; Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals; Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.	
Unit – IV	9
Understanding the harmony in the Nature; Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self-regulation in nature; Understanding Existence	

as Co-existence of mutually interacting units in all-pervasive space; Holistic perception of harmony at all levels of existence; Natural acceptance of human values; Definitiveness of Ethical Human Conduct; Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order; Competence in professional ethics.	

Text & Reference Books:

1. Andrews, C. (2006). *Slow is beautiful*. New Society Publishers.
2. Gandhi, M. K. (1909). *Hind Swaraj or Indian Home Rule*. Navjeevan Trust.
3. Gandhi, M. K. (2009). *An Autobiography or The Story of My Experiments with Truth* (Mahadev Desai, Trans.). Navjeevan Mudranalay. (Original work published 1925).
4. Gaur, R. R., Sangal, R., & Bagaria, G. P. (2010). *A Foundation Course in Human Values and Professional Ethics*. Excel Books.
5. Govindrajan, M., Senthilkumar, S., & Natarajan, M. S. (2013). *Professional Ethics and Human Values*. Prentice Hall India.
6. Kumarappa, J. C. (2017). *Economy of Permanence.* Sarva Seva Sangh Prakashan.
7. Naagarazan, R. S. (2022). *A Textbook on Professional Ethics and Human Values*. New Age International.
8. Rolland, R. (2010). *Life of Vivekanad* (4th Ed.). Advait Ashram.
9. Schumacher, E. F. (1973). *Small is beautiful. A study of Economics as if people mattered*. Blond & Briggs.
10. Suresh, J., & Raghavan, B. S. (2003). *Human Values and Professional Ethics*. S Chand.

BSM-160		**Engineering Mathematics II**
Course category	:	Basic Sciences & Maths (BSM)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number 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	:	The course is aimed at developing the basic mathematical skills of engineering students that are imperative for effective understanding of engineering subjects.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. To solve the ordinary differential equations.
2. To solve the partial differential equations using Lagrange and charpit's method.
3. To solve and understand the properties of Bessel`s and Legendre`s differential equation.
4. Application of partial differential equation in real life problems
5. To solve ODE and PDE with the help of Laplace transform
6. To inculcate the habit of mathematical thinking and lifelong learning.

Topics Covered

UNIT-I: Ordinary Differential Equations I	9
Linear differential equations with constant coefficients($n^{th} order$), complementary function and particular integral. Simultaneous linear differential equations, solution of second order	

differential equations by changing dependent and independent variables, Method of variation of parameters, Applications of differential equations to engineering problems	
UNIT-II: Ordinary Differential Equations II	9
Series solution of second order differential equations with variable coefficient (Frobeneous method). Bessel and Legendre equations and their series solutions, Properties of Bessel function and Legendre polynomials.	
UNIT-III: Partial Differential equations	9
Partial differential equations of the first order, Lagrange's solution, Charpit's general method of solution, Partial differential equations of the second order: Constant coefficient and reducible to constant coefficient, Classification of linear partial differential equations of second order.	
UNIT-IV: Laplace Transform	9
Laplace Transform, Laplace transform of derivatives and integrals. Unit step function, Laplace transform of Periodic function. Inverse Laplace transform, Convolution theorem, Applications to solve simple linear and simultaneous differential equations and Partial Differential Equations.	

Books & References

1. B.S. Grewal: Higher Engineering Mathematics; Khanna Publishers
2. Erwin kreyszig: Advanced Engineering Mathematics, John Wiley & Sons.
3. R. K. Jain and Iyenger: Advanced Engineering Mathematics, Narosa Publications.
4. B.V. Ramana: Higher Engineering Mathematics, Tata Mc. Graw Hill Education Pvt. Ltd.
5. M.D. Raisinghania, Ordinary and Partial Differential Equations. S Chand Publications.

BSM-190		**Environmental Science and Green Chemistry**
Course category	:	Basic Sciences & Maths (BSM)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial : 0 , Practical: 2
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through home assignments, quizzes, one minor test, practical work, viva-voce, practical exam and major theory Examination
Course Objectives	:	Understanding the principles and concepts of Chemistry viz. Chemical Bonding, acidity and basicity, Atmospheric Chemistry & Water Chemistry, Spectroscopic analytical methods and Green Chemistry and solving industrial problems using solid foundation in Chemistry.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. To develop the concepts of basic chemistry.
2. To make the students aware of global environmental issues e.g. global warming & Greenhouse effect, Ozone depletion, pollution and its prevention and understand various aspects of atmospheric chemistry.
3. To understand the analytical and conceptual skills required for environmental chemistry research.
4. To understand water treatment for all types of uses and need to protect environment.
5. To understand the specifications of pure water and its purification techniques.

6. To develop the knowledge about Green Chemistry and Green Technology.	
Topics Covered	
UNIT-I: Basic Chemical Concepts	9
Periodic properties of elements, Ionization potential, electron affinity and electronegativity; mole concept, molarity and normality, Chemical Bonding – MO Theory, MO diagram of diatomic molecules, hydrogen bonding, electrophiles, nucleophiles, inductive effect and mesomeric effect. Reaction Mechanism. Acidity and basicity - Concept of pH.	
UNIT-II: Atmospheric chemistry & Water Chemistry	9
The atmosphere of Earth, layers of atmosphere and temperature inversion, Air pollution, Global warming and Greenhouse effect. Acid rain and Ozone layer depletion. Chemical and photochemical Smog. Sources of water, conservation of water, impurities in water and their effects. WHO guideline and BIS guideline for drinking water. Hardness of water, Softening of water by Zeolite process, Lime Soda process, Ion exchange process and Reverse osmosis.	
UNIT-III: Spectroscopic analytical methods	9
Absorbance, Transmittance and Beer-lamberts Law. Basic principles of UV-Visible spectroscopy, Fluorescence spectroscopy, Infrared spectroscopy, NMR Spectroscopy. Use of these instrumental techniques for monitoring of environmental pollution. Environmental problems posed by the use of non-biodegradable polymers widely used in day-to-day life. Incineration as the key method for disposal of polymeric waste. Bio-degradable polymers.	
UNIT-IV: Green Chemistry	9
Green Chemistry and Green Technology: New trends in Green chemistry; Green Chemistry Methodologies-Microwave heating, ultrasound technique. Green Chemical Synthesis Pathways; Green reagents, Green solvents.	

List of experiments:

1. Determination of temporary and permanent hardness in water sample using EDTA as standard solution.
2. Determination of alkalinity in the given water sample.
3. Determination of chloride content in the given water sample by Mohr's method.
4. Determination of percentage of available chlorine in bleaching powder sample.
5. Determination of iron content in the given sample using $K_3[Fe(CN)_6]$ as an external indicator.
6. Determination of Electrical conductivity/TDS of a given water sample using conductivity meter.
7. Determination of dissolved Carbon Dioxide of given water sample.
8. Determination of the biochemical oxygen demand of sewage influent.
9. To calculate the lambda max of the given compound by using UV-Visible spectrophotometer.
10. Determination of nickel / cobalt / copper solutions by UV–visible spectrometry.
11. Examples of Green Synthesis /Reactions.
12. Determination of Turbidity of Water
13. Iodoform test
14. Synthesis of a polymer Bakelite or Polyacrylic acid.

Books & References

1. A Text Book of Environment and Ecology, Shashi Chawla, Tata McGraw Hill
2. Environmental Studies, Raj Kumar Singh, Tata McGraw Hill

3. Engineering Chemistry, Wiley India
4. Engineering Chemistry, Tata McGraw Hill
5. Organic Chemistry, Morrison & Boyd, 6th edition, Pearson Education
6. Fundamentals of Environmental Chemistry, Manahan, Stanley E., Boca Raton: CRC Press LLC.
7. Environment and Ecology, R K Khandal, Wiley India
8. An Introductory Text on Green Chemistry: For Undergraduate Students, lndu Tucker Sidhwani, Rakesh K. Sharma, Wiley
9. A text book of Green Chemistry, Shankar Prasad Deo and Nayim Sepay, Techno World Publication.

Introduction to Green Chemistry, John Andraos, Albert S. Matlack, CRC Press

BEE-107/ 157		**Basic Electrical Engineering**
Course category	:	Engineering Fundamentals (EF)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 0, Practical: 2
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through attendance, home assignments, quizzes, practical work, record, viva voce, Minor test and One Major Theory & Practical Examination.
Course Objectives	:	**1.** To demonstrate and understand the basic knowledge of electrical quantities such as current, voltage, power, energy, and frequency to understand the impact of technology in a global and societal context. **2.** To demonstrate and understand the basic concepts of analysis of simple DC and AC circuits used in electrical engineering and apply the basic concepts in Electrical engineering for multi-disciplinary tasks.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course:

1. Understand the basic properties of electrical elements, and solve problem based on basic electrical circuits & DC network theorems.
2. Understand the fundamental behaviour of AC circuits and solve AC circuit problems.
3. Apply the knowledge gained to explain the behaviour of the circuit at series & parallel resonance of circuit & the effect of resonance.
4. Classify different electrical measuring equipment's and understanding their principles.
5. Understand the basic concepts of magnetic circuits.
6. Explain construction and working principle of transformer.

Topics Covered

UNIT-I: D C Circuit Analysis and Network Theorems	9
Circuit Concepts: Concepts of network, Active and passive elements, Voltage and current sources, Concept of linearity and linear network, Unilateral and bilateral elements, R, L and C as linear elements, Source transformation, Kirchhoff's laws, Loop and nodal methods of analysis, Star-delta transformation, Network theorems: Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum Power Transfer theorem.	

UNIT-II: Steady- State Analysis of Single-Phase AC Circuits	9
AC fundamentals: Sinusoidal, square, and triangular waveforms – Average and effective values, Form and peak factors, Concept of phasor, phasor representation of sinusoidally varying voltage and current, Analysis of series, parallel and series-parallel RLC Circuits, Resonance in series and Parallel circuit Three Phase AC Circuits: Three phase system-its necessity and advantages, Star and delta connections, Balanced supply and balanced load, Line and phase voltage/current relations, three-phase power, and its measurement	
UNIT-III: Measuring Instruments & Magnetic Circuit	9
Types of instruments, Construction and working principles of PMMC and Moving Iron type voltmeters & ammeters, Use of shunts and multipliers. Magnetic circuit, concepts, analogy between electric & magnetic circuits, B-H curve, Hysteresis, and eddy current losses.	
UNIT-IV: Single-Phase Transformers	9
Single Phase Transformer: Principle of operation, Construction, EMF equation, Power losses, Efficiency, O.C & S.C Test and Introduction to auto transformer.	

List of experiments:

1. Verification of Kirchhoff's Law.
2. Verification of Norton's Theorem.
3. Verification of Thevenin's Theorem.
4. Verification of Superposition Theorem.
5. Verification of Maximum Power Transfer Theorem.
6. Verification of Series R-L-C circuit.
7. Verification of Parallel R-L-C circuit.
8. Measurement of Power and Power factor of three phase inductive load by two wattmeter method.
9. To perform O.C. and S.C. test of a single-phase transformer.

Books & References

1. Fundamentals of Electric Circuits, C.K. Alexander and M.N.O. Sadiku; TATA McGraw-Hill.
2. Principles of Electrical Engineering, V. Del Toro; Prentice Hall International.
3. Electrical and Electronics Technology, Edward Hughes; Pearson.
4. Basic Electrical Engineering, D P Kothari, I.J. Nagarath; Tata McGraw Hill
5. Electrical Technology, B. L. Thareja and A. K. Thareja; S. Chand.

BME-157		**Engineering Graphics with AutoCAD**
Course category	:	Professional Skill
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 2, Tutorial: 0, Practical: 4
Number of Credits	:	4
Course Assessment Methods		Continuous assessment through attendance, home assignments, quizzes, practical work, record, viva voce, Minor test and One Major Theory & Practical Examination.

Course Objective	:	This course aims at the following educational objectives: Comprehend general projection theory, with emphasis on orthographic projection to represent three- dimensional objects in two-dimensional views (principal, auxiliary, sections). Dimension and annotate two-dimensionalengineering drawings.
Course Outcomes	:	The students are expected to be able to demonstrate thefollowing knowledge, skills and attitudes after completing this course

1. How Engineering Drawing helps to sketch the imagination?
2. Able to effectively practice the different scales for drawings.
3. Effectively analyze the geometrical shapes and to be able to draw.
4. Know about out solids and discuss about their classification.
5. How to implement the different views for a solid placed in 3dspace.
6. Construction of the object from different perspective.

Topics Covered

UNIT-I: Conic Sections and Orthographic Projections Introduction	**6**

Introduction to Engineering Drawing covering, Principles of Engineering Graphics and theirsignificance, usage of Drawing instruments, lettering, Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid and Involute; Scales – Plain, Diagonal and Vernier Scales.

Orthographic Projections

Orthographic Projections covering Principles of Orthographic Projections- Conventions
Projections of Pointsand lines inclined to both planes; Projections of planes inclined Planes -Auxiliary Plane

UNIT-II: Projection of Regular Solids	6

Projections of Regular Solids covering those inclined to both the Planes- Auxiliary Views

UNIT-III: Sections and Sectional Views of Right Angular Solids	6

Sections and Sectional Views of Right Angular Solids covering, Prism, Cylinder, Pyramid, Cone – AuxiliaryViews; Development of surfaces of Right Regular Solids - Prism, Pyramid,Cylinder and Cone

UNIT-IV: Isometric Projections	6

Isometric Projections covering, Principles of Isometric projection – Isometric Scale,Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions. Overview of computer graphics, demonstrating knowledge of the theory of CAD software.

List of experiments

1. To perform lettering practice using BIS standards, including capital letters, small letters, and numerals
2. To construct a Cycloid, Epicycloid, Hypocycloid, and Involute of a Circle for the given dimensions.
3. To draw the orthographic projections of a regular solid (Prism, Pyramid, Cylinder, or Cone) inclined to both HP and VP using the auxiliary view method.

4. To obtain the auxiliary view of a given regular solid and show its true shape and dimensions.
5. To draw the sectional views of a cylinder or cone using the auxiliary view method.
6. To develop the lateral surface of a Prism, Pyramid, Cylinder, or Cone for the given dimensions.
7. To draw the development of a truncated solid after sectioning by an inclined plane.
8. To draw the isometric projection and isometric view of the given simple or compound solid using an isometric scale.
9. To explain the principles of computer graphics and the theory of CAD software, and prepare a simple engineering drawing using CAD tools.
10. To convert the given orthographic views into an isometric view and vice versa.

Text & Reference books:

1. Engineering Drawing-Bhat, N.D.& M. Panchal, Charotar Publishing House, 2008
2. Engineering Drawing and Computer Graphics- Shah, M.B. & B.C. Rana, Pearson Education, 2008
3. A Textbook of Engineering Drawing-Dhawan, R.K., S. Chand Publications,2007
4. Textbook on Engineering Drawing-Narayana, K.L. & P Kannaiah, Scitech Publishers, 2008

BHS- 102/152		**TECHNICAL WRITING AND PROFESSIONAL COMMUNICATION (TW&PC)**
Course category	:	HSS
Pre-requisite Subject	:	None
Contact hours/week	:	4
Number of Credits	:	: Lectures: 2, Tutorial: 1, Practical: 2
Course Assessment methods	:	: Continuous assessment through One test, teacher's assessment (quiz, tutorial, assignment, attendance), and One Major Theory Examination.
Course Objectives	:	The objectives of this course are to: - The course aims- 1. To sensitize the students to understand the role and importance of communication for personal and professional success. 2. To enable the learners to enhance their writing skills in techno-cultural and professional echo-system. 3. To equip learners to differentiate technical writing from general writing. 4. To equip them with technical writing skills. 5. To enable learners to exhibit knowledge, skills, attitude and judgment in and around human communication that facilitate their ability to work collaboratively with others in an interpersonal environment.
Course Outcomes	:	The students will be able to demonstrate the following knowledge, skills, and attitudes upon completion of the course

1. Overcome the problems she/he shall faces in oral and written communication.
2. Acquire knowledge of and methods for using technical communication, such as reports, proposals, technical letters, etc.

3. Use and Practice compositions correctly.
4. Give presentations in different sessions and make self-appraisal.
5. Learn and understand the various facets of Communication Skills, such as (LSRW) Listening, Speaking, Reading, and writing, and identify, formulate, and solve real-life problems with a positive attitude
6. Inculcate, the habit of learning and developing communication and soft skills.

Topics Covered

UNIT-I: Language and Communication	9

Language Vs communication: Communication as coding and decoding – signs, symbols & pictograph – verbal and non–verbal symbols – Language & communication; Types ofCommunication- functional, situational, verbal, and non-verbal, interpersonal, group, interactive, public, Mass Communication. Thinking and Articulation, critical, creative aspects of articulation.

Skills of Language Acquisition: Natural Language Acquisition Skills: Listening, Speaking, Reading& Writing {LSRW}; Language Acquisition Through Training: Listening, Speaking, Reading, Writing, Grammar & Vocabulary {LSRWGV}

Phrase, Clause & Sentence in Professional Drafting-Simplicity, Clarity and Conciseness of a Presentation, Differentiating between Professional and Creative Writing, Blending of Artistic/Professional Writing, Avoiding gender, racial, and other forms of bias in Professional Writing. Pre-writing, Drafting, and Re-writing.

UNIT-II: Towards Technical Writing	9

Technical Paper Writing: Professional Paper Elements-Front Matter of a Paper, Main Text of a Paper, End Matter of a Paper: Organizing References and Bibliography, Order of a thesis and Paper Elements, Concluding Remarks. **Methods of Research Paper Writing:** Identification of Author and His Writing-Author's name and Affiliation, Joint Authorship of a Paper, Identification of Writing- Title, Keywords, Synopsis, Preface and Abstract. Drafting Research Article & Methodology.

Thesis/Dissertation Writing: Thesis Elements-Front Matter of a Thesis, Main Text of a Thesis, End Matter of a Thesis, Specimen—Thesis and Research Paper, Chapters and Sections-Introductory Chapters and Sections, Statement of the Problems, Plan and Scope, Core Chapters and Sections-Theoretical Analysis and Synthesis, Basic Assumption and Hypothesis.

Professional Presentation & Seminar Delivery Tools: Designing the Presentation; Establishing the Objectives. Making Professional PowerPoint Presentations, Signaling Structure of Presentation through Sentences and Crisp Phrases, Preparing Notes for Professional/Technical Presentation, Text Animation, White Board, Flip Charts, Diagrams, Preparing Cards. Seminar Presentations: Purpose modes and methods. Nascent Emerging Platforms for On-line Presentations viz. Zoom, Webex, Team& Meet etc.

UNIT-III: Drafting Skills & Career Correspondence	9

Professional Drafting: Letters vs. e-mails, Formal and Informal emails, Parts of e-mails, Types of e-mails, Managing tone of E-mails and business Letters, Examples of Letters and E-mail, Professional Correspondence through E-mail, Job Applications and cover Letters. Introduction to DOs (Demi- Official Letters)

Career & Correspondence: Developing a Professional C.V, Bio Data & Resume. Report Writing, Kinds of Reports, Length of Report, Parts of a Report, Terms of Reference, Collection of Facts, Outlines of Report, Examples of Report, Technical Proposal, Elements of Proposal, Examples of Proposal, drafting of proposal.

UNIT-IV: Professional Practices with ICT Interface	9

Conducting Professional Meeting: Pre-meeting Preparation, During Meeting: Action Taken Report (ATR) & New Agenda Points, Post Meeting Follow ups. Notice, Circular, Agenda & Meeting Minutes. **Introduction to Generation–Z, Cyber Identity & Professional Netiquettes for Netizens:** DraftingE-mails, Blogs on social media, Videoconferencing. Managing Profiles on social media. What to Write and Share on social media. Telephone Etiquettes & Phubbing.

LIST OF EXPERIMENTS:

1. Introduction to Vowel and Consonant Sounds
2. Monophthongs and Diphthongs
3. Syllable, Word Stress & Intonation
4. Harnessing Non-verbal Communication Skills in Cross-Cultural Environment for the establishment of an ideal Ecosystem to ensure Professional Success
5. Developing Speech, and Proofreading the Same
6. Argumentative Skills & Group Dynamics
7. Preparing CV, Biodata & Resume
8. Types of Interview and Interview Skills
9. GD, PI & Telephonic Interview
10. Presentation Skills, Extempore, Debate and Video Conferencing
11. Netiquettes while Writing Blogs on social media.
12. Ethical Usages of Generative AI

Books & References

1. Acharya Anita. (2012) Interview Skills- Tips & Techniques. Yking Books, Jaipur.
2. Basu, B. N., (2008) Technical Writing. PHI Learning Pvt. Ltd.., New Delhi.
3. Chauhan, N. K & Singh, S. N. (2013) Formal Letters, Pankaj Publication International, New Delhi.
4. Chhabra T.N. (2018) Business Communication. Sun India Publication New Delhi.
5. Dubey Arjun et.al. (2016) Communication for Professionals. Alfa Publications, Delhi.
6. Gibaldi, Joseph (2021). The MLA Handbook for Writers of Research Papers. Ed. IXth, Modern Language Association of America, NY, US.
7. Gurumani, N. (2010) Scientific Thesis Writing and Paper Presentation, MJP Publishers, Chennai.
8. Hamilton Richard. (2009) Managing Writers. Penguin, India.
9. Mc Graw S. J. (2008) Basic Managerial Skills for All. Ed. 08th, Prentice Hall of India, New Delhi.
10. Murphy & Hildebrandt. (2008) Effective Business Communication. Tata McGraw Hill New Delhi.
11. Pandey, S.P., Singh, S. N. & Kumar, Raman, (2023) Exploring Digital Humanities: Challenges & Opportunities, MacBrain Publishing House, New Delhi.

BCH-124		**CREATIVITY FOR CHEMICAL ENGINEERS**
Course category	:	VAC/AC
Pre-requisite Subject	:	None
Contact hours/week	:	0
Number of Credits	:	Lectures: 0, Tutorial: 0, Practical: 2
Course Assessment methods	:	Continuous assessment through teacher assessment and end semester practical major examination.
Course Objectives	:	The objectives of this course are to: - 1. creativity and chemical engineering

		2. Define the problem. 3. Generate solution. 4. Generate creativity
Course Outcomes	:	The students will be able to develop
1. understand the role of creative thinking within the context of chemical engineering 2. appreciate the importance of environment and team dynamics in creative problem solving 3. be able to apply criteria to help define the real problem 4. be able to recognise mental blocks and initiate their removal by 'blockbusting' techniques 5. appreciate a range of creative processes for identifying solutions to the real problem 6. be introduced to the Kepner-Tregoe (KT) approach for selecting an appropriate solution		
Eight practices performed on following topics using advanced computational and laboratory 1. Creativity and engineering 2. Conditions and factors for creativity 3. Creative systems 4. Types of problem 5. Critical thinking 6. Present state/desired state 7. Statement/restatement 8. Lateral thinking 9. Organising and assessing ideas 10. Selling your ideas to others 11. An insight into how the brain works 12. Creativity enhancers and inhibitors 13. Team creativity		

BPT-085: BIOLOGY FOR CHEMICAL ENGINEERS	
Course Category	: Basic Science and Mathematics (BSM)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:0, Practical: 2
No of Credits	:4
Course Assessment Methods	: Continuous assessment through attendance, home assignments, quizzes, practical work, record, viva voce and one minor test and One Major Theory & Practical Examination.
Course Objectives	This course provides the knowledge and understanding of 1. Concepts of biological principal 2. Enzyme catalytical reaction 3. Stoichiometry of biological process 4. Basic concept of bioreactor design
Course Outcome	Students are expected to understand: 1. Basics of biology 2. Kinetics of enzyme catalysis reaction 3. Stoichiometry of biological process 4. Kinetics of substrate utilization 5. Design concept of bioreactors 6. Downstream/product recovery operations

Unit - I: Basics of Biology	9
Biophysics and the cell doctrine, structure of cells, types of cells, lipids, sugars and polysaccharides, nucleotides to RNA and DNA, amino acids to proteins, Hybrid biochemical.	
Unit - II: Kinetics of Enzyme catalysis reaction	9
Enzyme-substrate complex and enzyme action, enzyme kinetics, determination of elementary step reaction kinetics, enzyme activity, deactivation of enzyme, application of enzyme technology, immobilize enzyme technology and kinetics	
Unit - III: Stoichiometry and substrate utilization kinetics	9
Thermodynamic principles, metabolic reaction coupling, carbon catabolism, respiration, Photosynthesis, biosynthesis, transport across cell membrane, metabolic organization and cell membrane, end product metabolism, stoichiometry of cell growth and product formation. Ideal reactors for kinetics measurements, kinetics of balanced growth, transient growth kinetics, structured kinetics models, product formation kinetics, segregate kinetic model and death kinetics.	
Unit - IV: Design of bioreactor	9
Ideal bioreactors, reactor dynamics, reactor with nonideal mixing, sterilization reactors, immobilized reactors, multiphase bioreactors, fermentation technology, and product recovery operation.	
LIST OF EXPERIMENTS 1. To prepare broth media for microbial growth. 2. To culture the microbial organisms in a shake flask using orbital shaker incubator. 3. To estimate the Microbial biomass produced through shake flask culturing. 4. To plot Microbial growth curve for shake flask culturing using turbidity method. 5. To Estimate the Monod Parameters for microbial growth kinetics 6. Estimation of microbial count using plat count method 7. Temperature effect on growth-estimation of energy of activation and Arrhenius Constant for microorganisms. 8. Development of enzyme assays and quantification of enzyme activity and specific activity Effect of pH and temperature on enzyme activity 9. Techniques of enzyme immobilization - matrix entrapment, ionic and cross linking.	
References: 1. Bailey J. E., Ollis D. F., "Biochemical Engineering Fundamentals", McGraw Hill Book Company (1986). 2. 2. Blanch H. W., Clark D.S., "Biochemical Engineering", Marcel Dekker Inc. (1997). **3.** 3. Shuler M. L., Kargi F., "Bioprocess Engineering (Basic Concepts)" Prentice Hall of India, (2003).	

BCH-205: CHEMICAL ENGINEERING THERMODYNAMICS-I	
Course Category	: Professional Core (PC)
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

	1. Fundamentals of Thermodynamics Systems and variables 2. Thermodynamics diagrams and heat effects in chemical processes 3. Laws of thermodynamics 4. Thermodynamic cycles and Processes
Course Outcome	: At the end of the course the students will be able to:

1. Develop a fundamental understanding of the basic principles of chemical engineering thermodynamics and calculations.
2. Explain the PVT behaviour of fluids and different equation of states
3. Estimate the volumetric properties of real fluids
4. Estimate the heat effects in chemical process
5. Apply thermodynamic principles to the analysis of chemical processes and equipment such as turbines, compressors, heat pumps, and refrigeration cycles among others.
6. Evaluate changes in different thermodynamic properties for pure fluids using different techniques such as equations of state (EOS), tables, and charts.

UNIT I: INTRODUCTION	9
Introduction and Fundamentals of Thermodynamics Systems and variables, Work, Heat, Reversible and Irreversible Processes, internal energy, First Law: Closed and Open Systems, enthalpy, equilibrium state, phase rule, heat capacity specific heat, Steady and Transient Processes. Significance of Chemical Engineering Thermodynamics	
UNIT 2: PROPERTIES OF PURE SUBSTANCES	9
Thermodynamics diagrams; Equation of states; Generalized correlations and acentric factor; Estimation of thermodynamic properties. Mathematical relation among thermodynamic functions, Maxwell's relations, Interrelation between H, S, U, G, Cp and Cv	
UNIT 3: LAW OF THERMODYNAMICS AND HEAT EFFECTS	9
Concept of entropy, reversible heat engine, entropy change and irreversibility, laws of thermodynamics: their applications to real processes, Heat capacities of gases as a function of temperature of liquids and solids, sensible heat, heat of vaporization, heat of reaction etc.	
UNIT 4: THERMODYNAMICS OF FLOW PROCESS	9
Throttling process, flow through nozzles, turbine, compressor, and pump, Carnot refrigeration cycle, air refrigeration cycle, liquefaction processes.	

References

1. Smith J. M., Van Ness H. C., Abbott M.M., "Introduction to Chemical Engineering Thermodynamics", 7th Ed., McGraw-Hill, New York (2005).
2. Rao Y. V. C., "Chemical Engineering Thermodynamics", Universities Press Limited, Hyderabad (1997).
3. Kyle B.G. "Chemical & Process Thermodynamics", 2nd Ed., Prentice-Hall of India, New Delhi (1990).
4. Sandler, S.I., "Chemical and Engineering Thermodynamics", 2nd Ed., Wiley, New York (1989).
5. Tester J.W., Modell M., "Thermodynamics and its Applications", 3rd Ed., Prentice Hall (1999)

BCH-206: PROCESS CALCULATIONS

Course Category	Professional Core (PC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 0
No of Credits	:4
Course Assessment Methods	: Continuous assessment through attendance, home assignments, quizzes, and one minor test and One Major Theory Examination.
Course Objective	1. To understand basics of calculations 2. To understand how to apply the basics of calculations 3. To understand material and energy flow in the processes. 4. Application of basic calculation in process industries.
Course Outcome	Students are able to 1. Understand basic concept of material and energy balances 2. Understand concept of molecular weight, etc 3. Perform basic unit conversions and calculations 4. Perform material and energy balance calculations without and with chemical reaction 5. Perform energy balance calculations 6. Apply material and energy balance calculations to unit operations

UNIT 1: Mathematical Principles	9
Dimensions and system of units, Fundamental and derived units, Dimensional consistency, Dimensional equations, Different ways of expressing units of quantities and physical constant, Unit conversion and its significance. Calculations for mole, molecular weight, equivalent weight, etc., Composition of gaseous mixtures, liquid mixtures, solid mixtures, etc., Ideal gas law & other equations of state and their applications, Dalton law, Raoult's law, Henry's law, Solutions, and their properties.	
UNIT 2: Material Balance for Physical and Chemical Systems	9
Concept, material balance calculations, recycling and bypassing operations, introduction to unsteady state processes with examples like batch reactor, accumulation of inert components electrochemical reactions, recycling, and By-passing Operations.	
UNIT 3: Energy Balance	9
Concept, energy and Thermo chemistry, energy balances, heat capacity of pure substances and mixtures, latent heats, enthalpy of pure substances and mixtures, absolute enthalpy, heat of reaction, adiabatic reactions, thermo chemistry of mixing processes, dissolution, liquid-liquid mixtures, gas-liquid systems.	
UNIT 4: Stoichiometry and Unit Operations	9
Distillation, humidification, absorption and stripping, extraction and leaching, crystallization, Psychrometry, drying, evaporation, introduction to stoichiometry and industrial problems.	

References

1. Bhatt, B. L., Vora, S. M., "Stoichiometry", 4th Edition, Tata McGraw-Hill (2004).
2. Hougen, O. A., Watson, K. M and Ragatz, R. A., "Chemical Process Principles Part-I", John Wiley and Asia Publishing (1970).
3. Himmelblau, D. M., "Basic Principles and Calculations in Chemical Engineering", Fourth Edition, Prentice Hall Inc. (1982).

4. Whitwell J. C., Tone R. K., "Conservation of Mass and Energy ", McGraw-Hill (1973).
5. Process Calculation for Chemical Engineering, Second Revised Edition, Chemical Engineering Education Development Centre, I.I.T., Madras, 1981.
6. Narayanan K. V., Lakshmikutty B., "Stoichiometry and Process Calculations" PHI Learning Pvt Ltd., New Delhi (2016).

BCH-207: FLUID FLOW OPERATION	
Course Category	: Professional Core (PC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:0, Practical: 2
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through attendance, home assignments, quizzes, practical work, record, viva voce and one minor tests and One Major Theory & Practical Examination.
Course Objectives	This course provides the knowledge and understanding of 1. Basic concepts of fluid flow operations 2. Types of flows 3. Application different flow measuring devices 4. Basic concept and selection of pumping devices for fluid
Course Outcome	Students are expected to:
1. Apply basics equation to fluid flow operations 2. Apply knowledge of macroscopic balances 3. Understand compressible, incompressible fluids and liquid mixing 4. Understand fluid flow measurement device and calculations of pressure drop in pipelines 5. Understand concept of hydrodynamic boundary layer 6. Select device for pumping of fluids	
UNIT 1: Fluid Flow Basics	9
Fluid flow phenomena, Types of fluids, Basic equations of fluid flow: Macroscopic momentum balance, Macroscopic balance in potential flow: Bernoulli theorem and its application.	
UNIT 2: Compressible and Incompressible Fluids	9
Flow of incompressible fluids in pipes and closed channels, Process of compressible fluids, Liquid Mixing: Types of mixing patterns, mixing mechanism, and mixing equipments.	
UNIT 3: Fluid Flow Measurements	9
Devices for measurement of Pressure, Fluid flow measuring devices. Calculation of Pressure Drop in a Pipe, Minor Losses in Fittings. Concept of hydrodynamic boundary layer, growth over a flat plate, different thickness of boundary layer.	
UNIT 4: Pumping of Fluids	9
Hydraulic pumps: Positive Displacement Pumps, Reciprocating Pumps, Rotary Pumps and Screw Pumps. Centrifugal Pumps, Characteristic Curves of Centrifugal Pumps, NPSH. Centrifugal pumps verses Reciprocating pumps pump losses and Efficiencies, Multistage pumps, Work and power Input.	
List of Experiments	

1. To find the flow rate using a V notch.
2. To find the friction losses in a Straight and bend pipe.
3. Study of Pipe fittings and Valves.
4. To study the Reynolds apparatus and verify experimentally.
5. To study the working principle of a reciprocating pump and to determine the percentage of slip.
6. To study the working principle of a centrifugal pump and determine its efficiency experimentally.
7. To find out the flow profile of water from hook's gauge and determination of coefficient of velocity, coefficient of discharge, coefficient of resistance, coefficient of contraction.
8. To determine the pressure drop in a packed bed by Leva's and Ergun's equation and verify experimentally.
9. To determine the minimum fluidization velocity in a fluidized/tapered fluidized bed and verify experimentally.
10. Determination of discharge coefficient with Reynolds Number in case of an orifice meter and a venturi meter.
11. Study and verification of the flow pattern in a Bernoulli's apparatus.
12. Determination of the mixing, fluidization and segregation index of the given sample of bed materials in a fluidized bed.

Books

1. McCabe W., Smith J., "Unit Operations of Chemical Engineering", 7th Edition, McGraw Hill Education (2017).
2. Gupta V., Gupta S. K., "Fluid Mechanics and its Applications", Wiley Eastern, New Delhi (1984).
3. Shames I. H., "Mechanics of Fluids", 4th Edition, McGraw-Hill, Inc (2002)
4. Coulson J. M., Richardson J. F., "Chemical Engineering: Volume-I", 4th Edition, Pergamon Press (1990).
5. Jain A. K., "Fluid Mechanics including Hydraulic Machines", Khanna Publishers, Delhi (2007).
6. Geankoplis C. J., "Transport Processes and Unit Operations", 4th Edition, Prentice-Hall Inc (2004).

BCH-208: PARTICULATE TECHNOLOGY	
Course Category	: Professional Core (PC)
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	1. To impart knowledge about handling fine solid in chemical industry

	2. Introduce physical mechanisms and fundamental involved in mechanical separation processes 3. Introduce concepts and formulate mathematical model for solid-liquid, liquid-liquid based on mechanical separation 4. To understand working principle involved in various industrial operation viz Sedimentation tank, Filtration unit, clarification, and transportation etc.
Course Outcome	Students expected to:

1. Learn fundamental properties of solid fines particles
2. Analyse the sieving performances using different sieve size.
3. Acquired knowledge to select suitable equipment for size reduction of solids, conveying system for transportation solids
4. Able to determine the crushing efficiency of different size reduction equipment using crushing laws
5. Acquire knowledge about theory of filtration and calculate the filtration time, specific cake and medium resistance of filtration processes understand concept of fluidization
6. Acquire knowledge about agitation and different types of agitated vessels

UNIT I: Screening and size reduction of solids	9

Properties of solids, Performance of screening equipment/testing sieves, U.S. sieve series, Tyler standard sieve series, sieve shaker, types of screen analysis. Necessity of size reduction, crushing efficiency, energy requirement calculations by using crushing laws. Classification of size reduction equipment: Crushers, Dry versus wet grinding. Open and closed-circuit grinding.

UNIT 2: Settling and sedimentation	9

Motion of particle in fluid, drag force, drag coefficient. Gravity settling methods, Terminal falling velocity, Stoke's law and Newton's law of settling. Hindered settling, Gravity sedimentation operations, Sedimentation test, Kynch theory, Determination of thickener area and depth of thickener, Classification, Types of classification equipment.

UNIT 3: Mixing, agitation and fluidization	9

Flow through packed bed, Ergun equation, Blake palmer equation, Types of fluidizations, fluidized bed systems, determination of minimum fluidization velocity, and applications of fluidized bed. Introduction to fundamental Concepts of agitation and different types of agitated vessels

UNIT 4: Filtration and Conveying of Solids	9

Classification of filtration and filters. Theory of filtration-equations. Filter media and filter aids. Batch and continuous filters. Plate and frame filter press. Storage of solids, Conveyors: Principle, Construction and Working. Advantages, Disadvantages and design calculations of Belt Conveyors, types of conveyors, cyclone separator, electrostatic separator.

List of Experiments

1. Determination of average particle size of a mixture of particles by sieve analysis.
2. Study and operation of Jaw crusher and thereby verification of Ritinger's constant.
3. Determination the viscosity of fluid in falling ball viscometer
4. Determination of the effect of no of balls on grinding in a Ball mill and comparison of its critical speed with the operating speed.
5. To determine minimum fluidization velocity.
6. Study and operation of a Gyratory Crusher and thereby finding its reduction ratio.

7. To find the cake and filter medium resistance of Plate and Frame Filter press.
8. To find the filter medium resistance of a press and frame Filters in Rotatory vacuum drum filter.
9. To find out the efficiency of separation of cyclone separator.
10. To determine the Power required for mixing.

References:

1. Narayanan C. M., Bhattacharyya B.C., "Mechanical Operations for Chemical engineers" Khanna Publication (2014).
2. McCabe W., Smith J., "Unit Operations of Chemical Engineering", 7th Edition, McGraw Hill Education (2017)
3. Coulson & Richardson, "Chemical Engineering: Volume II", Pergamon Press (2002)
4. Coulson & Richardson, "Chemical Engineering: Volume I", Pergamon Press (2002)
5. Swain A.K., Patra H. & Roy G.K., "Mechanical Operations", Tata McGraw Hill Education Private Limited, New Delhi (2011)

BCH-257: CHEMICAL ENGINEERING THERMODYNAMICS-II	
Course Category	: Professional Core (PC)
Pre-requisite Subject	: Basic Thermodynamics, Process calculations
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 knowledge about 1. Fundamentals of chemical engineering thermodynamics for phase equilibrium 2. Solution properties on mixing in chemical processes 3. Appropriate models to calculate phase equilibrium problems 4. Chemical Reaction equilibrium
Course Outcome	: Students will be able to

1. Develop a fundamental understanding of the basic principles of chemical engineering thermodynamics for phase equilibrium
2. Compare ideal gas/solution models to reflect behaviour of real mixtures based on the concepts of chemical potential, fugacity, and excess free energy
3. Explain the Vapour-Liquid Equilibrium relations to solve the process separation
4. Evaluate the different methods/assumptions for performing phase equilibrium calculations
5. Apply the appropriate models to calculate phase equilibrium problems
6. Determine the equilibrium products and their concentration in equilibrium when dealing with systems involving chemical reactions.

UNIT 1: THERMODYNAMIC PROPERTIES OF FLUIDS	9

Single Phase Mixtures and Solutions; Partial molar properties, Gibbs- Duhem equation, chemical potential, Ideal and non-ideal mixtures/Solutions, fugacity, and fugacity coefficient for pure components and for mixture of gases and liquids. Lewis Randall rule, Henry's law.

UNIT 2: THERMODYNAMIC PROPERTIES OF MIXTURES	9
Excess properties of mixtures, residual properties, activity co-efficient, Excess Gibbs energy, Models for the excess Gibbs energy, Property changes of mixing, Heat effects of mixing processes, Heats of solution, Enthalpy-Concentration diagrams	
UNIT 3: PHASE EQUILIBRIUM	9
Importance of phase equilibria in process industries, vapour -Liquid equilibria (VLE) miscible, partially miscible and immiscible systems, Azeotropes, Phase rule, Phase Equilibrium Criteria, vapor-liquid equilibrium of ideal and non-ideal solution at low to moderate pressures, Raoult's Law and Modified Raoult's Law; Activity coefficients from experimental data -Margules, van-laar, Wilson Equations	
UNIT 4: CHEMICAL REACTION EQUILIBRIUM	9
Reaction coordinate, Chemical Reaction Equilibria, equilibrium constant (K), Relation of equilibrium constants to composition, equilibrium conversion (X), effect of Temperature & Pressure on K, evaluation of K, calculation of equilibrium compositions for single reactions, phase rule and Duhem's theorem for reacting systems, introduction of multi reaction equilibria.	

LIST OF EXPERIMENTS

1. Determine calorific values of solid, liquid and gaseous fuels. (Bomb calorimeter)
2. Determine the heat capacity ratio at constant volume and constant pressure
3. Determine the ratio of volumes using isothermal process
4. Study of vapor Pressure of Liquids
5. To investigate the effect of sensor on target temperature
6. Concepts of pressure measurement and calibration investigation
7. Calculate the coefficient of performance for the refrigeration machine and compare it with the coefficient of performance for the Carnot refrigeration cycle machine.
8. To study the rate of heat gained by calorimeter from the surroundings and its effect over the mean rate of heat extraction over the interval.
9. Study the operation of a vapor compression refrigeration unit. Calculate the mean rate of heat extraction over the interval, mass flow rate circulation of the refrigerant and capacity of refrigeration unit.
10. To prove Boyle-Marriott's law.
11. To determine Joule-Thomson coefficient of argon.

References

1. Smith J. M. Van Ness H. C., Abbott M.M., "Introduction to Chemical Engineering Thermodynamics", 6th & 7th Eds., McGraw-Hill, New York (2001) & (2005).
2. Sandler, S.I., "Chemical and Engineering Thermodynamics", 2nd Ed., Wiley, New York (1989).
3. Rao Y. V. C., "Chemical Engineering Thermodynamics", Universities Press Limited, Heydrabad (1997).
4. Kyle, B.G., "Chemical and Process Thermodynamics", 2nd Ed., Prentice-Hall of India, New Delhi (1990).
5. Koretsky, Milo D., Engineering and chemical Thermodynamics, John Wiley & Sons (Asia) Pte ltd., Singapore

AUC119: FUNDAMENTALS OF ARTIFICIAL INTELLIGENCE	
Course Category	: Audit Course (AC)
Pre-requisite Subject	: Basic Programming Knowledge
Contact hours/week	: Lecture: 2, Tutorial: 0, Practical: 0
No of Credits	: 0
Course Assessment Methods	Continuous assessment through assignments, quizzes, tutorials, course-based project, one minor test and one major examination
Course Objectives	: To impart knowledge about 1. Introduce fundamental concepts of Artificial Intelligence. 2. Develop basic Python programming skills for AI applications. 3. Build foundations in data analysis and preprocessing. 4. Provide understanding of machine learning concepts. 5. Expose students to AI use cases in various engineering domains.
Course Outcome	: Students will be able to

1. Understand fundamental concepts of Artificial Intelligence and intelligent systems.
2. Apply Python libraries for data handling and visualization.
3. Perform data pre-processing and exploratory data analysis.
4. Understand basic machine learning concepts and evaluation metrics.
5. Implement supervised and unsupervised machine learning algorithms.
6. Develop simple AI-based solutions using data preprocessing, visualization, and basic machine learning models.

UNIT 1: Introduction to AI and Python Programming	6

Overview of Artificial Intelligence: History, scope, types of AI, Applications of AI in modern technology, Python Basics: Data types, variables, operators, Control Structures: Conditional statements, loops, Functions and Modules, Data Structures: Lists, tuples, dictionaries, sets, File Handling Introduction to NumPy, Pandas, Matplotlib.

UNIT 2: Exploratory Data Analysis	6

Types of Data: Numerical and Categorical, Steps in Exploratory Data Analysis, Descriptive Statistics, Data Visualization Techniques, Introduction to Data-driven Decision Making.

UNIT 3: Data Pre-processing and Introduction to Machine Learning	6

Data Cleaning and Deduplication, Handling Missing Data, Data Transformation: Normalization, Scaling, Binning, Introduction to Supervised and Unsupervised Learning (Conceptual Only), And Model Evaluation Metrics: Accuracy, Precision, Recall, F1-score.

UNIT 4: AI Use Cases in Engineering	6

Supervised Learning Case Studies: Use of Linear Regression for product yield and conversion prediction, Logistic Regression for fault detection in reactors and separation units, Decision Trees and Random Forests for process optimization, and quality prediction. Support Vector Machines for nonlinear process modeling and classification, K-Nearest Neighbours and Naïve Bayes for chemical property prediction and process monitoring.

Unsupervised Learning Case Studies:K-means clustering for process identification and operational pattern. Hierarchical clustering for material and reaction similarity analysis.

Text Books (Recommended)

1. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, O'Reilly
2. Wes McKinney, Python for Data Analysis, O'Reilly

3. Ethem Alpaydin, Introduction to Machine Learning, MIT Press
4. Jake VanderPlas, Python Data Science Handbook, O'Reilly

Reference Books

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press
2. Sebastian Raschka, Machine Learning with Python, Packt
3. Stuart Russell & Peter Norvig, Artificial Intelligence: A Modern Approach, Pearson
4. Andreas C. Müller & Sarah Guido, Introduction to Machine Learning with Python, O'Reilly

BCH-258: HEAT TRANSFER OPERATION	
Course Category	: Professional Core (PC)
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 two minor tests and One Major Theory & Practical Examination.
Course Objective	1. To understand the fundamentals of heat transfer mechanisms 2. To understand the effect of heat transfer in process equipment's 3. To study the parameters affecting heat transfer. 4. Application mechanism of heat transfer in various heat transfer equipment.
Course Outcome	: Students are able to 1. Understand concept of conduction, convection, and radiations 2. To do design heat exchanger 3. Understand concept of evaporation operation 4. Calculate thickness of insulation 5. Understand modes of condensation 6. Understand concept of evaporators

UNIT 1: Conduction	9
Modes of heat transfer, Thermal conductivity, thermal insulation, units and dimensions. General differential equation of conduction, Steady state heat conduction, contact resistance, heat transfer between surfaces and surrounding, critical thickness of insulation. Heat transfer through extended surfaces of uniform cross section. Enhanced heat transfer: concept of fins, Fin efficiency.	
UNIT 2: Convection	9
Natural and forced convection, principal heat balance equation in laminar flow Empirical equations for convection heat transfer in turbulent flow through tubes, through annulus and over a flat plate. Dimensional analysis, dimensional groups used in heat transfer. Condensation: Modes and features, Nusselt's equation, condensation on vertical and horizontal plate Boiling: Pool boiling of saturated liquid, types of boiling, concept of critical heat flux.	
UNIT 3: Radiations	9
Thermal radiation, black body radiation, properties of radiation, laws of radiation. The radiation shape factor, various cases of radiation between two surfaces, radiation shields.	
UNIT 4: Heat Exchangers and Evaporators	9
Types of heat exchangers and evaporators and their process calculations; design of double pipe, shell and tube heat exchangers, and single and multiple effect evaporators.	

List of Experiments

1. To study heat transfer through lagged pipe.
2. To find out the thermal conductivity of liquid.
3. To study heat transfer in composite wall and find equivalent thermal conductivity.
4. To find out the convective heat transfer co-efficient of vertical cylinder in natural convection.
5. To determine convective heat transfer coefficient in forced convection.
6. To find out the overall heat transfer co-efficient of a double pipe heat exchanger.
7. To find out the overall heat transfer co-efficient of 1-2 shell & tube heat exchanger.
8. To study the heat transfer coefficient during drop wise and film wise condensation.
9. To study the heat transfer coefficient in a vertical and a horizontal condenser.
10. To find out the emissivity of a surface.
11. To find out the Stefan-boltzman constant and compare with the theoretical value.
12. Study and operation of a batch evaporator.

References

1. McCabe, W. L., Smith, J.C., Harriott, P. "Unit Operations of Chemical Engineering", 7th Edition, McGraw-Hill (2017)
2. Holman, J. P., "Heat Transfer", McGraw-Hill (1996)
3. Coulson, J. M. & Richardson, J. F., "Chemical Engineering: Vol-1", Butterworth – Heinemann (2002)
4. McAdams W. H., "Heat Transmission", 3rd Edition, Krieger Pub Co (1985).
5. Kern D. Q., "Process Heat Transfer", McGraw-Hill (1950).
6. Badger W. L. & Bancharo J. T., "Introduction to Chemical Engineering", Tata McGraw Hill (1955).
7. Rudramoorthy R. and Mayilsamy K. "Heat and Mass Transfer". Pearson (2010)

BCH-259: REACTION ENGINEERING – I	
Course Category	: Professional Core (PC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 4, 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	This course provides the knowledge and understanding of: 1. Kinetics of homogenous reactions 2. Design protocol isothermal reactor 3. Concepts of parallel and series reaction 4. Effect of temperature and pressure on reaction
Course Outcome	Students are expected to:
1. Understand kinetics of homogeneous reactions 2. Design isothermal reactors	

3. Derive kinetics for parallel reactions
4. Derive kinetics for series reaction
5. Understand temperature and effects on reaction
6. Choose right kind of reactor

UNIT 1: Kinetics of Homogeneous Reactions	9

Rate of Reaction, Molecularity and order of reaction, Mechanism of reaction, temperature dependency from thermodynamics, Integral and differential methods for analyzing kinetic data. interpretation of constant volume reactor, zero, first, second and third order reactions, half-life period, irreversible reaction in parallel and series, catalytic reaction, auto catalytic reaction, reversible reactions.

UNIT 2: Design of Isothermal Reactor	9

Design of batch, continuous stirred tank, plug flow reactors, optimization of reactor size, reactors in series/parallel, recycle reactor, reactor design for multiple reactions.

UNIT 3: Parallel and Multiple Reactions	9

Design of parallel reactions, Irreversible first order reactions in series, first order followed by zero order reaction, zero order followed by first order reaction, successive irreversible reactions of different orders, reversible reactions, irreversible series-parallel reactions

UNIT 4: Temperature and Pressure Effect	9

Non isothermal reactor design, the steady state energy balance and adiabatic PFR applications.

List of Experiemnts

1. Second order reaction
2. Pseudo First order reaction
3. Batch reactor: Second order reaction
4. Batch reactor: Pseudo first order reaction
5. Study of second order reaction for unequal concentration of reactants
6. Arrhenius Law
7. Continuous stirred tank reactor
8. Plug flow reactor
9. To study operation of an adiabatic batch reactor
10. To study combined Flow Reactor
11. To study cascade Continuous Stirred Tank Reactor

Textbooks:

1. Smith J. M., 'Chemical Engineering Kinetics', 3rd Edition, McGraw-Hill (1990).
2. Levenspiel, O., 'Chemical Reaction Engineering', 3rd Edition, John Wiley (1998).

Reference Book:

1. Keith J. Laidler, 'Chemical Kinetics', 3rd Edition, Pearson (2013)
2. Coulson and Richardson's, 'Chemical Engineering Volume III', 3rdElsevier (2006)

BCH-260: MASS TRANSFER-I	
Course Category	: Professional Core (PC)
Pre-requisite Subject	: Basic Thermodynamics, Process calculations
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	1. To impart knowledge about the basic concepts and fundamentals of mass transfer processes. 2. To introduce the fundamental laws and theories of mass transfer processes across interphase 3. To enable the student to learn about the gas-liquid equilibrium operations. 4. To impart knowledge about working of various mass transfer equipment like, gas absorption columns, dryers, cooling towers and dryers used in chemical industries
Course Outcome	Students are able to

1. Understand concept of molecular diffusion and mass transfer theories
2. Understand multicomponent diffusion
3. Acquire knowledge to estimate diffusion coefficients and mass transfer rates
4. Able to design absorption and cooling towers
5. Understand the humidification processes and use of psychometric chart to design dryer
6. Understand crystallization process and design of crystallizer

UNIT 1: Diffusion	9

Introduction to Mass transfer operation, Diffusion: Fick's law of diffusion, Steady state molecular diffusion in fluids under stagnant and laminar flow conditions, Diffusion through variable cross-sectional area, Diffusion coefficient: measurement and prediction, Multi component diffusion, Diffusivity in solids and its applications. Introduction to mass transfer coefficient, Equimolar counter-diffusion, Correlation for convective mass transfer coefficient, Correlation of mass transfer coefficients for single cylinder, Theories of mass transfer, Penetration theory, Surface Renewal Theory, Boundary Layer Theory, Interphase mass transfer theory, Overall mass transfer coefficient.

UNIT 2: Humidification and dehumidification	9

Humidification & Dehumidification: Vapour liquid equilibrium and enthalpy for a pure substance, vapour pressure temperature curve, Vapour gas mixtures, Definition and derivations of relationships related with humidity Fundamental concept of humidification, Dehumidification and water cooling, Wet bulb temperature, Classification and design of cooling towers.

UNIT 3: Absorption	9

Absorption: Introduction, Absorption & Stripping: Equipment's, Gas-liquid equilibria, Henry's law, Selection of solvent, Absorption in tray column, Graphical and analytical methods, Absorption in packed columns, HTU, NTU & HETP concepts, Design equations for packed column. Murphee efficiency, plate efficiency.

UNIT 4: Drying	9

Drying: Solid-gas equilibria, Different modes of drying operations, Definitions of moisture contents, Types of batch and continuous dryers, Rate of batch drying, Time of drying, Mechanism of batch drying, Continuous drying, Crystallization: Equilibrium Yield of Crystallization, Theories of crystallization, Heat and Mass Transfer rates in crystallization.

List of Experiemnts

1. Determination of diffusivity of acetone in air.

2. Determination of diffusivity of acetic acid in water.
3. Determination of rate of diffusion of spherical shape Naphthalene ball.
4. Rate of drying in forced convection condition.
5. Water cooling tower
6. Humidification/dehumidification
7. Wetted wall column.

References

1. Treybal R., "Mass Transfer Operations", 3rd Ed, McGraw-Hill: New York: (1980).
2. Dutta B.K., "Principles of Mass transfer and Separation Processes", Prentice-Hall of India, New Delhi (2007).
3. Geankoplis, C. J., "Transport Processes and Unit Operations", 3rd Ed, Prentice Hall. (1993)
4. Coulson & Richardson, 'Chemical Engineering Vol. II', Pergamon Press, 2002
5. McCabe, W. L., Smith, J. C., "Unit Operations of Chemical Engineering", 3rd Ed, McGraw-Hill (1976)
6. Banchero J.T., Badger, W.L., "Introduction to Chemical Engineering", McGraw-Hill Inc. (1955)
7. Dutta B.K., "Principles of Mass transfer and Separation Processes", Prentice-Hall of India, New Delhi (2007).

BCH-305: CHEMICAL TECHNOLOGY		
Course Category	: Professional Core (PC)	
Pre-requisite Subject	: NIL	
Contact hours/week	: Lecture: 3, Tutorial:0, Practical: 2	
No of Credits	:3	
Course Assessment Methods	: Continuous assessment through attendance, home assignments, quizzes, and minor test and One Major Theory Examination.	
Course Objective	1. To understand various manufacturing processes used in process industries 2. To understand difficulty encountered in process industries 3. To understand process factors like yield, by-products, waste generation 4. To understand process operation through flow diagrams.	
Course Outcome	: Students able to understand 1. Pulp & paper and chemicals derived from coal 2. Petrochemicals and fertilizers 3. Sulphur and chloro-alkali industries 4. Petroleum and polymer synthetic fibre 5. Fuel and gas technology 6. Polymer and synthetic fiber	
UNIT I: Pulp and paper, Coal chemicals		**9**
Pulp and Paper: Raw materials, pulping processes, recovery of chemicals, stock preparation and paper making. Coal Chemicals: Various processes for obtaining coal chemicals, coal tar distillation, F-T and Bergious processes for hydrocarbon production.		

UNIT II: Petrochemicals	**9**
Petrochemicals: Manufacturing processes of formaldehyde, acetaldehyde, acetic acid, acetic anhydride, maleic anhydride, nitrobenzene, ethylene oxide, ethylene glycol. Pesticides: Processes for manufacturing of insecticides, fungicides, and herbicides. Fuel and Industrial Gases: Technology options of producing producer gas, syn gas, pyro gas, nitrogen, oxygen, and carbon dioxide.	
UNIT III: Sulphur and chlro-alkali	9
Sulphur Industries: Origin and extraction of sulphur, production routes of sulphuric acid and oleum. Phosphorous Industries: Manufacturing of phosphorus, phosphoric acid and phosphatic fertilizers. Chlor-Alkali Industries: Production of common salt, caustic soda, chlorine, hydrochloric acid, and soda ash. Nitrogen Industries: Manufacturing of ammonia, nitric acid, nitrogenous and mixed fertilizers. Explosive and Propellants.	
UNIT IV: Petroleum, Polymer, and synthetic fiber	**9**
Petroleum Industry: Origin, occurrence and characteristics of crude oil, crude oil distillation and secondary processing. Polymer and Synthetic Fibre: Introduction to polymerization, commodity polymers, rayon, polyester, polyamide, acrylic fibre, and nylons.	
List of experiments 1. Preparation of Pigments 2. Preparation of Para red, Fluorescein, methyl orange, orange-II, and resorcinol dyes. 3. Preparation of Phenolphthalein, Bakelite (phenol-formaldehyde resin), and Nylon-6. 4. Preparation and saponification of soluble and insoluble soaps. 5. Synthesis of Aspirin (acetylsalicylic acid) and Paracetamol. 6. Nitration of benzene to produce nitrobenzene.	
References 1. Gopala Rao M., Marshall S, 'Dryden's Outlines of Chemical Technology', Affiliated East-West Press Pvt Ltd (1997) 2. Austin G. T., 'Shreve's Chemical Process Industries', 5th Edition, McGraw Hill (1984). 3. Moulijn J.K, Makkee M., van Diepen A, 'Chemical Process Technology', 2nd Edition, Wiley (2013).	

BCH-306: REACTION ENGINEERING-II	
Course Category	: Professional Core (PC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:0, Practical: 2
No of Credits	:4
Course Assessment Methods	: Continuous assessment through attendance, home assignments, quizzes, and minor test and One Major Theory Examination.
Course Objective	This course provides the knowledge and understanding of: 1. Non-ideal reactors 2. Catalytic reactors 3. Fluid-fluid reactions 4. Fluid-particle reactions

Course Outcome	Students are expected to: 1. Able to understand concept of RTD for ideal and real reactors 2. To derive mathematical model for real reactors 3. Understand concept of catalytic reactor and design 4. Understand concept of fluid-fluid reactor 5. To design fluid-fluid reactor 6. Understand concept of fluid-particle reactors and to design fluid-particle reactor

Unit - I: Non-ideal flow reactors	**9**
RTD for ideal reactors, RTD for real reactors, Properties of RTD functions, Conversion from RTD, Mathematical model for real reactors: Dispersed plug flow model and, tank in series model.	
Unit - II: Catalytic reactors	**9**
Catalysts, steps in catalytic reactor, synthesising a rate law, mechanism and rate-limiting steps, heterogeneous data analysis for reactor design, reaction engineering in microelectronics fabrications, catalyst deactivation	
Unit - III: Fluid-Fluid Reactions	9
Kinetic rate equations, rate equation for straight mass transfer (absorption) of A, rate equation for mass transfer and reaction, role of the Hatta Number, kinetic regime from solubility data, Design: Factors to consider in selecting a contactor, straight mass transfer, mass transfer plus not very slow reaction	
Unit IV: Fluid-Particle Reactions	**9**
Selection of a model: Progressive-Conversion Model, Shrinking-Core Model, shrinking-core model for spherical particles of unchanging size, rate of reaction for shrinking spherical particles.	

List of Experiments

1. To study performance of CSTR connected in series
2. To study performance of PFR & CSTR in Series
3. R.T.D. Studies in Plug Flow Reactor
4. R.T.D. Studies in CSTR
5. R.T.D. Studies in Packed Bed Reactor
6. Semi Bath Reactor
7. Condensation Polymerization Reactor
8. Fluidized Bed Reactor
9. Modeling and simulation of CSTR
10. Modeling and simulation of PFR
11. Modeling of kinetic reactions

References:

1. J. M. Smith, “Chemical Engineering Kinetics”, McGraw Hill College, 3rd Edition (1981)
2. H. S. Fogler, “Elements of Chemical Reaction Engineering”, Prentice Hall of India Pvt Ltd, 4th Edition (2008)
3. O. Levenspiel, “Chemical Reaction Engineering”, John Wiley, 3rd Edition (2006)
4. C. G. Hill, “An Introduction to Chemical Engineering Kinetics & Reactor Design”, John Wiley, 2nd Edition (1994)
5. B. Viswanathan, S. Sivasanker, A. V. Ramaswamy, “Catalysis: Principles and Applications”, Alpha Science International, Ltd (2002)
6. R. A. Van Santen, Piet W. N. M. Van Leeuwen, Jacob A. Moulijn, Bruce A. Averill,

"Catalysis: An Integrated Approach", Elsevier Science, 2nd Edition (1994)
7. D. Kunii, O. Levenspiel, "Fluidization Engineering", Butterworth-Heinemann, 2nd Edition (1991)

BCH-307: MASS TRANSFER-II	
Course Category	: Professional Core (PC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:0, Practical: 2
No of Credits	:4
Course Assessment Methods	: Continuous assessment through attendance, home assignments, quizzes, and minor test and One Major Theory Examination.
Course Objective	1. Impart fundamental concepts of vapour liquid equilibrium. 2. Imparts concepts of relative volatility, nonideal deviation and azeotropes. 3. Imparts knowledge of determination of trays in distillation column 4. Impart knowledge on concepts of Liquid-liquid extraction, solid leaching, types of adsorption and adsorber design.
Course Outcome	Students expected to gain knowledge on 1. Basic concepts of vapour-liquid, solid-liquid, and liquid-liquid equilibrium. 2. Types of adsorption isotherms 3. Design distillation column 4. Design liquid-liquid extraction 5. Design solid-liquid extraction column 6. Design adsorption column

UNIT 1: Distillation	**9**
Basics of distillation, Pressure-composition, Temperature-concentration, Enthalpy-concentration diagrams for ideal and non-ideal solutions, Raoult's law, boiling mixtures, volatility, Single Stage Distillation Differential distillation, Flash vaporization, Vacuum, molecular and steam distillation.	
UNIT 2: Continuous distillation of binary mixtures	**9**
Multistage contact operations, multistage tower, McCabe Thiele method, PonchonSavarit method, Reflux, reflux, tray efficiency, height and column diameter calculation, Multistage batch distillation, Principles of azeotropic in distillation. Introduction of multicomponent distillation.	
UNIT 3: Liquid-liquid and solid-liquid mass transfer operations	**9**
Liquid-Liquid Extraction: Ternary liquid equilibria, Triangular graph, theoretical or ideal stage, Equipment for single stage and multistage continuous operation, analytical and graphical solution of single and multistage operation. Solid /Liquid Extraction: Leaching, Solid liquid equilibrium, Equipment for solid – liquid extraction, single and multistage cross current contact and counter current operations, concept of ideal stage, overall stage efficiency, number of stages determination.	
UNIT IV: Adsorption	**9**
Basics of adsorption, Types of adsorptions, Nature of adsorbents adsorption equilibria and adsorption hysteresis, Stage wise and continuous contact adsorption operations, determination of number of stages, Ion exchange, Equipment, Equilibrium relationship, Principle Ion exchange, Phase Equilibrium relationship, Rate of Ion-exchange. Fundamental of membrane separation	

process.

List of experiments

1. Simple batch distillation process
2. Determine Plate efficiency
3. Bubble cap distillation column
4. Packed bed distillation apparatus
5. Determination of ternary curve for the system acetic acid-water-carbon tetrachloride.
6. Solid-Liquid extraction determine the equilibrium curve of extraction in toluene, acetic acid and water system
7. Determination of adsorption kinetics and isotherm at solid-liquid interface.

References:

1. Treybal R., "Mass Transfer Operations", 3rdEdition, McGraw-Hill: New York: (1980).
2. Geankoplis, C. J., "Transport Processes and Unit Operations", 3rdEdition, Prentice Hall. (1993)
3. Coulson & Richardson, "Chemical Engineering Vol. II", Pergamon Press, 2002
4. McCabe, W. L., Smith, J. C., "Unit Operations of Chemical Engineering", 3rd Ed, McGraw- Hill (1976)
5. Banchero J.T., Badger, W.L., "Introduction to Chemical Engineering", McGraw-Hill Inc.(1955)
6. Dutta B.K., "Principles of Mass transfer and Separation Processes", Prentice-Hall of India, New Delhi (2007).

BHS-303/353 Industrial/Organizational Psychology

Course Category	: HSSE
Prerequisite subject	: None
Number of Credits	: 4
Contact Hours/Week	: Lectures: 3, Tutorial: 1, Practical: 0
Course Assessment Methods	: Continuous assessment through One test, teacher's assessment (quiz, tutorial, assignment, attendance), and One Major Theory Examination.
Course Objectives	: The objectives of this course are to: - 1. Provide students with a foundational understanding of the principles, theories, and research methods in the field of I/O psychology. 2. To help students to understand the process of personnel management (selection, training, performance appraisal, development) while also introducing the psychological assessment methods crucial for effective personnel selection, job analysis, and employee evaluation. 3. To help students to analyse the multifaceted influences on workplace behaviour (motivation, job satisfaction, leadership dynamics, organizational culture) and to explore organizational dynamics (structure, communication patterns, decision-making processes), and strategies for effective change management.

	4. To provide opportunities for students to apply I/O psychology principles to real-world scenarios.
Course Outcomes	: The students will be able to demonstrate the following knowledge, skills, and attitudes upon completion of the course: - 1. Demonstrate a clear understanding of key concepts and theories in the field of I/O psychology, including their historical development and contemporary relevance. 2. Identify and propose solutions to workplace problems using evidence-based approaches grounded in I/O psychology principles. 3. Apply knowledge and skills acquired in the course to real-world situations, such as improving employee performance, enhancing team effectiveness, and promoting organizational change. 4. Demonstrate awareness of ethical issues and professional standards, and apply ethical principles to decision-making in the workplace.

Unit 1
Introduction to Industrial Psychology: Definition, scope, brief history, various sub divisions; Research in Industrial Psychology; Scientific Management Theory; Human Relations School; Managerial Roles, Functions & Skills; Effective vs Successful managers; Job Analysis and Evaluation; Employee Selection: Recruitment, Realistic Job Previews, Effective Employee Selection Techniques, Job Search Skills; Employee Selection: References and Testing. **[9]**
Unit 2
Evaluating Employee Performance; Designing & Evaluating Training Systems; Performance Management; Employee Retention, Engagement, and Careers; Organizational Development and Change Management; Employee Relations: Ethics and Employee Rights, Labor Relations and Collective Bargaining, Managing Global Human Resources, Managing Human Resources in Small and Entrepreneurial Firms. **[9]**
Unit 3
Motivation: Concept, theories and application; Emotions at workplace; Attitudes and Job Satisfaction; Perception: Components, process, factors that influence it, person perception, individual decision making; Personality: Determinants, theories and measurement; Stress: Sources, consequences and management. **[9]**
Unit 4
Foundations of Group Behavior: Types of groups, properties, decision making in groups; Understanding work teams: Types, creating effective teams; Communication: Functions, process, modes and organizational communication; Leadership: Concept, theories, finding and creating effective leaders; Power & Politics; Conflict & Negotiation. **[9]**
Text & Reference Books: 1. Aamodt, M. G. (2010). *Industrial/Organizational Psychology: An Applied Approach*. Wadsworth Cengage Learning. 2. Aswathappa, K. (2008). *Human Resource Management*. Tata McGraw Hill. 3. Chitale, A. K., Mohanty, R. P., & Dubey, N. R. (2019). *Organizational Behavior: Text and Cases*. Prentice Hall India. 4. Dessler, G., & Varrkey, B. (2020). *Human Resource Management*. Pearson. 5. Luthans, F. (2010). *Organizational Behavior*. McGraw Hill. 6. McShane, S. L., Glinow, M. A. V., & Rai, H. (2022). *Organizational Behavior*. McGraw Hill. 7. Muchinsky, P. M. (2006). *Psychology applied to work: An introduction to industrial and organizational psychology*. Hypergraphic Press.

8. Pareek, U. (2004). *Understanding Organisational Behaviour*. Oxford University Press.
9. Robbins, S. P., Judge, T.A., & Vohra, N. (2019). *Organizational Behavior*. Pearson.
10. Spector, P. E. (2016). *Industrial and Organizational Psychology: Research and Practice*. Wiley.

BCH-354: PROCESS EQUIPMENT DESIGN	
Course Category	: Professional Core (PC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:0, Practical: 2
No of Credits	:4
Course Assessment Methods	: Continuous assessment through attendance, home assignments, quizzes, and minor test and One Major Theory Examination.
Course Objective	1. To acquire basic understanding of design parameter 2. To understand knowledge of design procedures used for process equipment 3. To understand different types of equipment testing methods. 4. To understand the applicability and difficulty of different process equipment.
Course Outcome	: Students are expected to: 1. Design non-pressure and pressure vessels 2. Design tall vessels and support 3. Design shell and tube heat exchangers 4. Mechanical design of distillation 5. Mechanical design of absorptions columns 6. Economics parts of chemical engineering design

UNIT I: Design Pressure Vessels	**9**
Design of non-pressure storage vessel, tall vertical vessels, unfired pressure vessels with internal pressure, Design of unfired pressure vessels with external pressures, end closures, flat plates, domed ends, torispherical, ellipsoidal, hemispherical, and conical ends	
Unit II: Design of Heat Exchangers	**9**
Classification of heat exchanger, material of construction, cleaning of heat exchangers, heat transfer fluid, description of shell, tubes, pass partition plate, nozzle, baffles, tie rods, baffle spacers, flanges, gaskets etc. Design of heat exchangers: Energy balance, heat duty consideration and process design of double pipe and shell and tube heat exchangers	
Unit III: Design of mass transfer equipment	**9**
Mechanical design of tall vessels for distillation and absorption columns, packed and tray type towers. Tray Hydraulics: Bubble cap columns, perforated plate columns and packed towers. Process Design: Process design of tray and packed towers	
Unit IV: Agitators and mixing	**9**
Types of agitators, their selection, applications, baffling, agitator shaft diameter calculations which includes twisting moment, equivalent bending moment, power requirement calculations for agitation systems	

LIST OF EXPERIMENTS

1. Practice to design any four equipment's based on syllabus 'to scale' using AutoCAD software

2. Prepare specification datasheets for following equipment Vessel data sheet
    a. Double pile heat exchanger data sheet
    b. Shell and tube heat exchanger data sheet
    c. Distillation column data sheet
    d. Absorption column data sheet
    e. Pressure vessel data sheet
    f. Agitator data sheet

References:

1. Kern D. Q., "Process Heat Transfer", McGraw Hill, (2001).
2. Perry's, "Handbook of Chemical Engineering" McGraw Hill, 7th Edition, (1997).
3. Coulson J. M., Richardson R. E., "Chemical Engineering" Vol. 2 and 6, Pergamon Press (1998).
4. Van Winkle M., "Distillation", McGraw Hill Company, New York (1967).
5. Ludwig E. E., "Applied Process Design for Chemical and Petrochemical Plants", Vol. 1, 2 and 3, 3rd Edition, Gulf Publishing Company, Houston, (1995).
6. Bhattacharya B. C., "Chemical Equipment Design", CBS Publisher, (1985).
7. Sinnott R. K., Coulson & Richardson, "Chemical Engineering, Vol.6", 2nd Edition, Butterworth Heinemann, Oxford, (1998)

BCH-355: TRANSPORT PHENOMENA	
Course Category	: Professional Core (PC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 0
No of Credits	:4
Course Assessment Methods	: Continuous assessment through attendance, home assignments, quizzes, and minor test and One Major Theory Examination.
Course Objective	This course provides the knowledge and understanding of: 1. concept of viscosity, thermal conductivity, and diffusivity 2. shell momentum, heat and mass balances understand concept of interphase momentum, heat, and mass transport 3. concept interphase transport system
Course Outcome	Students are able to 1. Understand concepts of viscosity, thermal conductivity, and diffusivity 2. Calculate velocity distribution based on concept of shell momentum transport and equation of motion 3. Calculate temperature distribution based on concept of shell energy balance and equation of energy 4. Calculate temperature distribution based on concept of shell mass balance and equation continuity for multi-component systems 5. Understand analogies of heat, mass and momentum transport 6. Understand theories of mass transfer

UNIT 1: Momentum Transport	**9**
Vectors/Tensors, Newton's law of viscosity, Temperature, pressure and composition dependence	

of viscosity, Kinetic theory of viscosity, Shell momentum balance and its application, boundary conditions, equation of continuity, equation of motion	
UNIT 2: Heat Transport	**9**
Fourier's law of heat conduction, Temperature, pressure and composition dependence of thermal conductivity, Kinetic theory of thermal conductivity, Shell energy balance, boundary conditions and its application, equation of energy for forced and free convection.	
UNIT 3: Mass Transport	**9**
Fick's law of diffusion, Temperature, pressure and composition dependence of diffusivity, Kinetic theory of diffusivity, Shell mass balance and its applications	
UNIT 4: Interphase Transport	**9**
Introduction to the concept of heat and mass transfer coefficients. Interphase mass transfer, various coefficient of mass transfer and their determination, resistance concept, controlling phase concept, Mass transfer in turbulent flow, Analogies of mass transfer, Empirical equations. Theories of mass transfer, two film theory, Higbies penetration theory, Derivation of flux equation, surface renewal theory	

References:

1. Bird R. B., Stewart W.E., Lightfoot E.N., "Transport Phenomena" 2nd Edition, John Wiley & Sons (2002)
2. Beek W. J., Muttzall K. M. K., Heuven J. W. V., Transport Phenomena., 2nd Edition, John Wiley & Sons (2000)
3. Plawsky J. L., "Transport Phenomena Fundamentals", 3rd Edition, Marcel Dekker, New York (2014)
4. Brodkey R.S., Hershey H.C., "Transport Phenomena: A Unified Approach" McGraw-Hill (1989)

BCH-356: PROCESS CONTROL & INSTRUMENTATION	
Course Category	: Professional Core (PC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:0, Practical: 2
No of Credits	:4
Course Assessment Methods	: Continuous assessment through attendance, home assignments, quizzes, and minor test and One Major Theory Examination.
Course Objective	This course provides the knowledge and understanding of: 1. Open-loop systems 2. Closed-loop systems 3. Stability analysis 4. Advanced control system strategies
Course Outcome	Students are expected to: 1. Apply the concept of open loop transfer function to first order and second order systems 2. Understand concepts of controllers, final control elements and closed loop transfer function 3. Apply concepts of stability to feed-back systems 4. Design control system using frequency response 5. Understand basics of advanced control strategies

	6. Able to do control valve sizing

UNIT-I: Linear Open Loop Systems	**9**
Response of first order systems, Physical examples of first-order systems, Response of first order system in series and Second order system	
Unit II: Linear Closed-Loop Systems	**9**
The control systems, controllers and final control elements, closed-loop transfer functions, transient response of simple control systems	
Unit III: Stability Analysis of feed-back control systems	**9**
Concept of stability, stability criterion, Routh test for stability, concept of root locus, Introduction to frequency response: Substitution rule, Bode Diagram, Control system design by frequency response: Bode stability criteria, Gain and Phase margin, Ziegler-Nichols Controller settings.	
Unit IV: Process Applications	**9**
Cascade Control, Feedforward control, Ratio Control, Dead-time compensation, Internal model control, Controller tuning, tuning rules, process identification, control valve construction, valve sizing, valve characteristics, valve positioner.	

List of Experiments

1. Study of step response of first order (thermometer)
2. Study step second order system (mercury manometer & water manometer)
3. Step response of two first order systems: arranged in non-interacting mode and interacting mode.
4. Calibration of thermometer and thermocouple
5. Simulation of pressure control loop
6. Level control trainer
7. Programmable logic control trainer
8. I to P and P to I converter
9. Control system design using Matlab-Simulink
10. pH controller
11. Control valve characteristics

References

1. G. Stephanopoulos, "Chemical Process Control: An Introduction to Theory and Practice", Prentice Hall India Learning Private Limited (2008)
2. D. R. Coughanour, "Process System Analysis & Control", Mc Graw Hill, 3rd Edition (2013)
3. B. Wayne Bequette, "Process Control Modelling, Design & Control", PHI Publication (2003)
4. D. E. Seborg, T. F. Edgar, D. A. Mellichamp, "Process Dynamics & Control", Wiley Interscience (1989)
5. Babatunde A. Ogunnaike, W. Harmon Ray, "Process Dynamics, Modeling & Control", Oxford University Press Inc. (1994)
6. M. Chindambaram, "Computer Control of Processes", Alpha Science International Ltd. (2002)
7. Bella G. Liptak, "Instrument Engineers Handbook (Process Control)", CRC Press, 4th Edition (2003)

BMS-302/352		ENGINEERING ECONOMICS AND FINANCIAL MANAGEMENT
Course category	:	BMS
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor Test and one Major Theory Examination.
Course Objectives	:	To enable students to understand the fundamental economic concepts and basics of financial management needs for engineering students.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge and skills after completing this course.

1. Students should be able to acquire foundational knowledge of Engineering Economics and Financial Management and understand their relevance to engineering decision-making.
2. Students should be able to develop theoretical and empirical skills to analyse economic and financial data for managerial decisions.
3. Students should be able to demonstrate a basic understanding of microeconomics.
4. Students should be able to analyse demand and elasticity in engineering projects.
5. Students should be able to compare market structures and infer pricing/output strategies.
6. Students should be able to apply time value of money, assess risk-return, and evaluate investments using capital budgeting technique including risk adjustments.

Topics Covered

UNIT-I

Introduction to Engineering Economics: Nature and Scope of Engineering Economics, its integration with other streams.

Demand Analysis: Concept of Demand & its determinants. Price, Income, Substitution Effect, Elasticity of demand: Meaning, types, measurement and significance of engineering economics in managerial decisions. **[9]**

UNIT-II

Cost: Various Cost Concept and Classification, Cost Output Relationship in short and Long run cost Curves, Economies and diseconomies of Scale.

Pricing: Nature of market, Types of markets and their characteristics, pricing under different market structures-Perfect, Monopoly, Oligopoly, and Monopolistic Competition in engineering industry. **[9]**

UNIT-III

Introduction to Financial Management: Nature, scope and objectives of financial management related to engineering projects, Time value of money, Risk and Return, Profitability vs shareholders Wealth Maximisation, Capitalisation Concept. **[9]**

UNIT-IV

Capital Budgeting: The Capital Budgeting Process, Cash Flow Estimation for Engineering projects, Payback Period Method, Discounted Payback Period Method, Accounting Rate of Return, Net Present Value, Net Terminal Value, Internal Rate of Return, Profitability Index.**[9]**

Text & Reference books:

1. D.N. Kakkar, Managerial Economics for Engineering, PHI publication, New Delhi
2. D. N Dwivedi, Managerial Economics, Vikas Publication.
3. H L Ahuja, Managerial Economics, S Chand & Co. New Delhi

4. I. M. Pandey, Financial Management, Vikas Publication & Pearson
5. R. P. Rustagi, Financial Management, Taxmann's
6. M Y Khan & P K Jain, Financial Management, McGraw Hill

BCH-371: MINOR PROJECT-I	
Course Category	: Project (P)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 0, Tutorial:0, Practical: 0
No of Credits	:0
Course Assessment Methods	Continuous assessment through attendance, two Viva-voce, project work/record, and Major project Examination.
Course Objective	1. Impart knowledge to utilized chemical Engineering technical concepts through problem formulation. 2. Impart knowledge to formulate mathematical model. 3. Impart knowledge to assess thermodynamic stability, kinetic rate 4. Impart knowledge to apply concepts of momentum, heat mass transport used in chemical industries process.
Course Outcome	Students are expected to: 1. Demonstrate a sound technical knowledge of their selected project topic. 2. Undertake problem identification, formulation, and solution. 3. Design engineering solutions to complex problems utilising a systems approach. 4. Assessed thermodynamic feasibility through material and energy balance of process block diagram 5. Design and optimize major equipment's in the selected project 6. Demonstrate the skills, knowledge, and attitudes of a professional engineer.

The student can also choose a state-of-the-art problem of their own interest based on the recent trends in Chemical Engineering / Science in consultation with the guide. They shall work on the designated problem either individually or in groups (no of students in groups decides by faculty).

During the first term the students are required to:

1. Define the project problem.
2. Write a project proposal including concise introduction of latest published papers in the following order– a. Project title b. Introduction c. Origin of the problem d. Literature review of research and development at national & international level e. Significance of the problem f. Objective g. Methodology h. Details of collaboration (if any)
3. Carry out preliminary investigations if any or product design or process design etc.
4. Summarize the results (if any). The student is required to prepare a month wise work plan (for both semesters) immediately after the allotment of the project and the department is required to maintain a progress report of every student/project. The progress report should reflect monthly progress done by the student as per the work plan. The progress report is to

be duly signed by the respective project guide by giving the remarks/marks/grades etc. on the periodic progress done by the student should submit the project report at the end of respective terms to the examiners as a supporting document for evaluation.

Every student will be examined orally based on the topic of his/her project and relevant area to evaluate his understanding of the problem and the progress made by the student during the term. Students should submit a neatly typed and spiral bound research proposal at the end of the first term in the following format. Font: Times New Roman, Font size: 12, Headings: 14, Spacing: 1.5, typed on one side of the A4 size paper with proportionate diagrams, figures, graphs, photographs, tables etc. Referencing style: 1. Guo J. X. and Gray D. G., Chiroptical behaviour of (acetyl)(ethyl)cellulose liquid-crystalline solutions in chloroform, Macromolecules, 22, (1989), 2086. (Reference numbers should be mentioned in the main text as a superscript) The proposal should contain: 24 Page 1: The cover page - should mention: Project title, Name of the student, Name of the guide, Exam seat number and Year. Page 2: Certificate Page 3: Index Page 4 onwards: Research proposal (as above), experimental investigation details and result if any. Last page: References The department should prepare a template of the format of the project report and supply it to the students so as to maintain the uniformity in the project reports. Students are encouraged to participate and present their project work in various events, competitions, conferences and seminars etc. in consultation with their guide. **Note: The project guides are required to educate the students about antiplagiarism policy of MMMUT and apply the same while doing the project.**

BCH-441: MINOR PROJECT-II	
Course Category	: Project (P)
Pre-requisite Subject	: BCH-371: MINOR PROJECT-I
Contact hours/week	: Lecture: 0, Tutorial:0, Practical: 12
No of Credits	:6
Course Assessment Methods	Continuous assessment through attendance, two Viva-voce, project work/record, and Major project Examination.
Course Objective	1. Impart knowledge for writing a detailed project planning, materials, and budget requirement. • 2. Impart knowledge to build and test a prototype- design for real time implementation 3. Impart knowledge to make feasible, affordable prototype 4. To focus on sustainable, and efficient prototype solution
Course Outcome	: Students are expected to: 1. Demonstrate a sound technical knowledge of their selected project topic. 2. Co-design a prototype through methodologies and engage participatory to finalise a solution. 3. Understand lab-scale implementation and validation of their engineering concepts to solve complex problems. 4. Validation of the solution on the basis thermodynamic

	feasibility, material and energy balance of process block diagram 5. Identify and optimize parameters and learn project management to effectively manage the resources. 6. Demonstrate the skills, knowledge, and attitudes of a professional engineer.

During the second term (Minor Project -II) the students are required to:

1. Minor Project Part-I can be extended or may Carry out new detailed work base on previously defined (Project Part-I) project problem. The students may choose a prototype project on the areas
   - Agriculture Management
   - Energy & Environment
   - Water & Sanitation
   - Health & Hygiene
   - Waste Management etc.
2. Write a Project Report, which should be broadly divided into the following sections define by the supervisor

Font: Times New Roman, Font size: 12, Headings: 14, Spacing: 1.5, typed on one side of the A4 size paper with proportionate diagrams, figures, graphs, photographs, tables etc.

Referencing style: 2. Guo J. X. and Gray D. G., Chiroptical behavior of (acetyl)(ethyl)cellulose liquid-crystalline solutions in chloroform, Macromolecules, 22, (1989), 2086.

(Reference numbers should be mentioned in the main text as a superscript) The Project Report should contain in the following order:

1. The cover page –must mention: Project title, Name of the student(s), Name of the guide, Exam seat number and Year.
2. Certificate from guide
3. Certificate from industry (if any)
4. Index
5. Detailed Project Report having sections ‘a’ to ‘g’ from above.

Student is required to prepare a month wise work plan (for both semesters) immediately after the allotment of the project and the department is required to maintain a progress report of every student/project. The progress report should reflect monthly progress done by the student as per the work plan. The progress report is to be duly signed by the respective project guide by giving the remarks/marks/grades etc. on the periodic progress done by the student at the mid of the term and should be submitted along with project report at the end of respective terms to the examiners as a supporting document for evaluation.

Each student is required give presentation of his work for 20 minutes using 20-22 slides. The presentation will be followed by question answer session of 5 min. The department/university will provide template of the format of the project report and supply it to the students so as to maintain the uniformity in the project reports.

Students are encouraged to participate and present their project work in various events, competitions, conferences and seminars etc. in consultation with their guide.

Evaluation and assessment of marks will be done on basis of presentation of Co-design, a Prototype, Testing & Evaluation of Model, Research/conference Paper produced, Final Report and Presentation.

Note: Students must check plagiarism policy of MMMUT, Gorakhpur and apply the same while doing the project.

ICH-401: INDUSTRIAL PRACTICES	
Course Category	: Industrial Practice (IP)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 0, Tutorial:0, Practical: 20
No of Credits	:10
Course Assessment Methods	Continuous assessment through attendance, two Viva-voce, project work/record, and Major project Examination.
Course Objective	The students will acquire knowledge about. 1. Utilization of Chemical Engineering concepts 2. Formulation of mathematical model and assess thermodynamic stability, kinetic rate 3. Applying concepts of momentum, heat mass transport used in chemical industries processes 4. Report writing
Course Outcome	Students are expected to: 1. Demonstrate a sound technical knowledge of their selected IP topic. 2. Undertake Industrial problem identification, formulation, and solution. 3. Design engineering solutions to complex industrial problems utilising a systems approach. 4. Apply material and energy balance if required in industries 5. Frame process block and instrumentation diagram in industries 6. design and optimize major equipment's in the selected industry 7. Demonstrate the skills, knowledge, and attitudes of a professional engineer in solving industrial problems.

Industrial Practice is a regular study requirement, representing a compulsory part of the Chemical Engineering graduation Programme. The purpose of Industrial Practice is to adapt the student's knowledge to the requirements of the commercial and public sectors, and to train students to the extent that upon employment, they will be capable of integrating productively into the work of companies and institutions, while offering those organisations a chance to seek out and shape their future human resources.

Industrial Practice must enable students to integrate rapidly and productively into the work process at a future employer, to learn the basic Chemical Engineering functions and organisation of the company, to build upon and enhance theoretical and practical knowledge acquired through study to date at MMMUT, Gorakhpur and to perform work independently and under a mentor in specific fields of Chemical Engineering.

Industrial Practice lasts for 4 weeks without a break and is generally pursued in the summer semester of the third year. Industrial Practice is conducted under the guidance of a mentor at the Faculty and a mentor at the selected company, institution or department thereof where the field of work is mainly related to Chemical Engineering. Students can seek out for themselves the company or institution at which they will perform Industrial Practice, or they can be helped in this by the Coordinator of Training and Placement at MMMUT, Gorakhpur. The mutual obligations of the Faculty, student and company or institutions are defined in detail in a mutual cooperation agreement. The content of the Industrial Practice is defined in a programme composed for the individual student by the mentor at the Faculty and the mentor at the company or institution. At the

end of the
Industrial Practice the student produces a final report on the performance of specific tasks. The report and the quality of the tasks performed represent the basis for assessing the student's success. The final grade for Industrial Practice is given by the mentor at the Faculty in cooperation with the mentor at the company or institution on the basis of a proposed final grade and the submitted final report, and the company or institution issues a certificate of Industrial Practice performed.

PROGRESS OF ACTIVITIES AND TIMETABLE

1.Selection of mentor at the Faculty and registration for Industrial Practice

The student agrees with one of the Faculty teaching staff on mentorship for Industrial Practice. The student confirms the agreement between the teacher and student by selecting the teacher/mentor via the Online/offline Classroom.

The Coordinator of Training and Placement advises students in connection with their choice of company or institution at which the student should perform Industrial Practice. Registration and performance of Industrial Practice are not contingent on exams passed or other study requirements.

Deadline: no later than 1 month before the start of the Industrial Practice

2. Selection of company or institution, mentor at the company or institution and signing the Industrial Practice agreement

Industrial Practice is pursued either at companies or institutions whose primary field of work involves Chemical Engineering fundamentals and at large companies or institutions with their R& D centres or process plants.

Students generally seek out for themselves the company or institution at which they will perform Industrial Practice, or they can be helped in this by the Coordinator of traong and placement at the Faculty.

The company or institution assigns the student a mentor who holds at least level VI education and experience in the field of Chemical Engineering. By the stated deadline the student agrees with the Coordinator of Training and Placement on the selection of company or institution and the mentor at the company or institution. The company or institution confirms its willingness to cooperate in a declaration on cooperation.

The student brings a completed declaration by the stated deadline to the Coordinator of Training and Placement, who on that basis draws up an Industrial Practice agreement. The agreement defines the mutual obligations of the student, company or institution and Faculty.

Deadline: no later than 2 weeks before the start of the Industrial Practice

3. Industrial Practice programme preparation

The content of the Industrial Practice is defined in a programme composed by the mentor at the company or institution in cooperation with the student. The mentor at the Faculty reviews the content of the programme and confirms it. By the stated deadline the student agrees with the two mentors on the content and implementation of the programme.

The student delivers the original copy of the signed programme to the Coordinator of Training and Placement, and a copy of the approved programme to the two mentors.

Deadline: 2 weeks before the start of the Industrial Practice

4. Performance of Industrial Practice

Students can also perform Industrial Practice later, if owing to study or other obligations, the needs of the company or institution or for other reasons it is not possible to perform Industrial Practice in the summer semester of the third year.

During the Industrial Practice the mentor at the company or institution provides care for the student in the form of briefing them on the objectives and organisation of the company or institution and

on the requirements and work in the relevant position, and assigns to the student one or more appropriate technical tasks to resolve.

5. Final report and assessment of Industrial Practice

At the end of the Industrial Practice the student produces a final report in two copies, which should be produced in line with the prescribed instructions. The student's final report is reviewed by the mentor at the Faculty in cooperation with the mentor at the company or institution. The final report should be reviewed first by the mentor at the company or institution. The student submits the final report by e-mail to the mentor and to the Coordinator of Industrial Practice at the Faculty for review and approval. The reviewed and approved final report is signed by the student and by the mentor at the company or institution.

Based on the final report and the quality of the tasks completed, the mentor at the company or institution gives a proposed final grade indicating the success of the students' Industrial Practice. At the end of the Industrial Practice the company or institution issues a certificate of Industrial Practice performed.

One copy of the final report is kept by the mentor at the company or institution, and one copy is submitted by the student to the Coordinator of Industrial Practice together with a copy of the proposed final grade of the company or institution mentor and the certificate of Industrial Practice performed from the company or institution.

The final grade for Industrial Practice is given by the mentor at the Faculty in cooperation with the mentor at the company or institution on the basis of the submitted final report and the proposed final grade from the mentor at the company or institution.

Deadline: 2 weeks after the conclusion of the Industrial Practice or in the event of necessary corrections to the final report, the deadline for submission of the final report is 1 month after the conclusion of the Industrial Practice.

Note: Students who fail to submit a final report, a copy of the proposed final grade of the mentor at the company or institution and a certificate of Industrial Practice performed within the deadline of one month following the conclusion of the Industrial Practice, must repeat the Industrial Practice.

Note: The Faculty advisors are required to educate the students about antiplagiarism policy of MMMUT, Gorakhpur and apply the same while preparing IP report.

ICH-481: MAJOR PROJECT	
Course Category	: Major Project (MP)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 0, Tutorial:0, Practical: 20
No of Credits	:10
Course Assessment Methods	Continuous assessment through attendance, two Viva-voce, project work/record, and Major project Examination.
Course Objective	Student able to formulate the research problem based on department minor course they learned and developed the methodological solution to research objective.
Course Outcome	Students are expected to: 1. Demonstrate a sound technical knowledge of their selected project topic. 2. Undertake problem identification, formulation and solution. 3. Design engineering solutions to complex problems utilizing a systems approach. 4. Do thermodynamic feasibility, material and energy balance of

	process block diagram 5. Design and optimize major equipment's in the selected project 6. Demonstrate the skills, knowledge, and attitudes of a professional engineer.

The student can also choose a state-of-the-art problem of their own interest based on the recent trends in Chemical Engineering / Science in consultation with the guide. They shall work on the designated problem either individually or in groups (no of students in groups decides by faculty).
During the first term the students are required to:
1. Define the project problem.
2. Write a project proposal including concise introduction of latest published papers in the following order– a. Project title b. Introduction c. Origin of the problem d. Literature review of research and development at national & international level e. Significance of the problem
f. Objective g. Methodology h. Details of collaboration (if any)
3. Carry out preliminary investigations if any or product design or process design etc.
4. Summarize the results (if any). The student is required to prepare a month wise work plan (for both semesters) immediately after the allotment of the project and the department is required to maintain a progress report of every student/project. The progress report should reflect monthly progress done by the student as per the work plan. The progress report is to be duly signed by the respective project guide by giving the remarks/marks/grades etc. on the periodic progress done by the student should submit the project report at the end of respective terms to the examiners as a supporting document for evaluation.
Every student will be examined orally based on the topic of his/her project and relevant area to evaluate his understanding of the problem and the progress made by the student during the term. Students should submit a neatly typed and spiral bound research proposal at the end of the first term in the following format. Font: Times New Roman, Font size: 12, Headings: 14, Spacing: 1.5, typed on one side of the A4 size paper with proportionate diagrams, figures, graphs, photographs, tables etc. Referencing style: 1. Guo J. X. and Gray D. G., Chi optical behavior of (acetyl)(ethyl)cellulose liquid-crystalline solutions in chloroform, Macromolecules, 22, (1989), 2086. (Reference numbers should be mentioned in the main text as a superscript) The proposal should contain: 24 Page 1: The cover page - should mention: Project title, Name of the student, Name of the guide, Exam seat number and Year. Page 2: Certificate Page 3: Index Page 4 onwards: Research proposal (as above), experimental investigation details and result if any. Last page: References The department should prepare a template of the format of the project report and supply it to the students so as to maintain the uniformity in the project reports. Students are encouraged to participate and present their project work in various events, competitions, conferences and seminars etc. in consultation with their guide.
Note: The project guides are required to educate the students about antiplagiarism policy of MMMUT and apply the same while doing the project.

SYLLABUS OF PROFESSIONAL ELECTIVE

ECH-101: FUNDAMENTALS OF FOOD SCIENCE AND HUMAN NUTRITION	
Course Category	: Professional 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 1. Fundamental concepts of food technology and recent trends of food processing industries in India. 2. Role of food in human nutrition and protection from various ailments. 3. Basic concepts of biology, chemistry, microbiology and biochemistry of foods. 4. Foster awareness of career prospects and professional opportunities available in the food science and nutrition sector.
Course Outcome	: At the end of the course the students will be able to:

1. Describe the status, market scenario, opportunities, and challenges of the Indian and global food processing industries.
2. Explain the composition of foods, their functional properties, causes of food spoilage, and fundamental principles of food preservation.
3. Interpret nutritional requirements, nutrient bioavailability, and processes of digestion, absorption, enrichment, fortification, and supplementation.
4. Identify and analyze major nutritional deficiencies and assess the nutritive value of foods.
5. Demonstrate understanding of basic biology and general microbiology relevant to food systems, including microbial structure, staining, growth-isolation, and control methods.
6. Evaluate the role of microorganisms in food spoilage and preservation, and apply basic microbiological concepts to ensure food quality and safety.

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

6. C. GOPALAN, B. V. RAMA SASTRI, S. C. BALASUBRAMANIAN, "Nutritive Value of Indian Foods" , ICMR
7. Lillian Hoagland Meyer, "Food Chemistry", CBS PUBLISHERS
8. Amihud Kramer, Bernard A. Twigg, "Quality Control for the Food Industry Fundamentals & Applications", Medtech; 3rd edition (1 March 2017).
9. N. Shakuntala Manay, "Foods Facts and Principles", NEW AGE (1 January 2008)
10. Michael **Pelczar, Jr, "Microbiology",** McGraw Hill Education; 5th edition (20 April 2001)
11. 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	: Professional 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 1. Basic knowledge of Principles of Food Preservation 2. Depth knowledge of Technologies based on these principles 3. Working principles, Advantages and Limitations of these processes
Course Outcome	: At the end of the course the students will be able to:

1. Understand the reasons/causes of food spoilage and the need for Food Preservation
2. Understand the basic principles of Food Preservation & technologies available for the same.
3. Understand the equipments associated with these processes and their working principle
4. Understand the suitable use of these technologies for practical purposes
5. Understand the impact of these process technologies on product and environment
6. Understand the latest developments in related process technologies

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	: Professional 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 1. Fundamental knowledge of bakery products 2. Basic knowledge about machinery and equipments involved 3. Brief introduction of recent developments in bakery product technology.
Course Outcome	: At the end of the course the students will be able to:

1. Acquire knowledge of bakery products.
2. Understand the importance and role of ingredients in bakery industry
3. Understand the technology involved in production of Bread, Biscuits, Cakes and other baked products.
4. Understand about the machinery involved in manufacture of these products.
5. Understand the types of defects in bakery products and their remedies
6. Understand the packaging requirements of bakery products

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.	

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

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)

ECH-701: DAIRY TECHNOLOGY	
Course Category	: Professional 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

	1. Technologies of processing of milk and milk products 2. Machinery and equipments involved. 3. Hygiene and sanitation practices in milk plant.
Course Outcome	: At the end of the course the students will be able to:

1. Understand the composition and properties of fluid milks.
2. Understand the processes related to storage, processing and distribution of milk.
3. Identifying the functioning of various equipments related to dairy industry
4. Explain the technology and principles involved in manufacture of milk products.
5. Elaborate the Byproducts of Dairy Industry and their effective utilization
6. Have knowledge regarding hygiene and sanitation practices in the milk and milk products industry.

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.

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

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)

ECH-901: FOOD PACKAGING AND STORAGE ENGINEERING	
Course Category	: Professional 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 1. Knowledge of packaging, package developments and packaging laws and regulations in food industries. 2. Knowledge of different types of packaging materials and their forms used in food packaging. 3. Knowledge about package performance and various testing of packaging materials. 4. Knowledge about storage of food and food products.
Course Outcome	: At the end of the course the students will be able to:
1. Understand basic concept of packaging, printing and packaging laws & regulations in food industries. 2. Understand different types of packaging material & their properties and 3. Apply the knowledge in packaging of various food commodities 4. Applying the selection of packages for specific food & agricultural commodities. 5. Analyze the performance and quality of packaging materials Analyzing 6. Understand the designing of storage structures for food commodities	
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

ECH-102: HYDROGEN FUEL CELL TECHNOLOGY	
Course Category	: Professional 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.

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

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

ECH-302: GREEN HYDROGEN PRODUCTION TECHNIQUES	
Course Category	: Professional 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, assignments, Methods Quizzes and Minor test and Major Theory 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. Economical 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.

List of Experiments

1. To study hydrogen generation via steam reforming of ethanol and analyze effect of temperature on hydrogen yield.
2. To evaluate hydrogen production from biogas ($CH_4 + CO_2$ mixture) using steam reforming.
3. To simulate methane steam reforming and calculate conversion efficiency.
4. To analyze alkaline/PEM electrolysis process and calculate hydrogen production rate.
5. To determine thermodynamic feasibility of hydrogen production reactions.
6. To determine extent of reaction during steam reforming using mole balance.
7. To calculate electrolyzer efficiency powered by renewable sources.
8. To estimate capital investment, operating cost, and maintenance cost of hydrogen production routes.
9. To evaluate pollutant indicator (Πg) and ecological efficiency (ε) for hydrogen production processes
10. To analyze hydrogen production from ethanol, biogas, and green algae considering carbon credit benefits.

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

ECH-501: BIOHYDROGEN PRODUCTION	
Course Category	: Professional Elective – V (PE-5)
Pre-requisite Subject	: Nil
Contact hours/week	: Lecture: 3; Tutorial: 1; Practical:0
No of Credits	:4
Course Assessment Methods	Continuous assessment through tutorials, assignments, Methods Quizzes and Minor test and 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	After completion of the course the student shall 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.

Unit – III: Hydrogen Production Processes	9

Photobiological Hydrogen Production, Photofermentation, Dark Fermentation, Hybrid 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. 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-701: HYDROGEN STORAGE AND TRANSPORT	
Course Category	: Professional Elective – VI (PE-7)
Pre-requisite Subject	: Nil
Contact hours/week	: Lecture: 3; Tutorial: 1; Practical: 0
No of Credits	:4
Course Assessment Methods	Continuous assessment through tutorials, assignments, Methods Quizzes and Minor test and 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	On completion of this course, students are 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	9

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. 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-901: Cryogenic Hydrogen Technology	
Course Category	: Professional Elective – 9 (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, 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

This course provides knowledge

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

ECH-103: ADVANCED POLYMERIC MATERIALS	
Course Category	: Professional 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 1. Newer polymers in wide applications 2. Basic concepts of various specialty polymers 3. 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. To understand and analyze the structure-property relationships of polymers 2. Ability to identify suitable polymer(s) for a given application 3. To understand the basics of various devices and applications in which advanced polymers are used 4. Applying fundamentals in formulating research problems and solving them’	
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.
6. A. K. Bhowmick, Ed., Current Topics in Elastomers Research, CRC Press, USA. 2008.

ECH-303: ADVANCED METHODS OF MATERIALS CHARACTERISATION	
Course Category	: Professional 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, and one minor tests and One Major Theory Examination.
Course Objectives	: To impart the knowledge of 1. Basic concepts of Materials Characterization. 2. Fundamentals of physicochemical characterisation of materials. 3. Basic principles, operating mechanism of various analytical techniques. 4. Applications of charactrization technologies.
Course Outcome	: At the end of the course the students will be able to:
1. Understand the basic principles for different characterization techniques 2. Explain the principles and operation of a range of advanced techniques such as X-ay, spectroscopic, microscopic, thermal and electroanalytical, currently used in characterisation of various materials and compounds. Capable of applying various transport models for the calculation of membrane fluxes and the other of separation properties for various membrane systems. 3. Hand on experience of operation of some these instruments at labs and interpretation of results 4. Apply the skills gained in future course of research in materials science	
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.
4. Introduction to Photoelectron Spectroscopy, P.K.Ghosh, John Wiley.
5. 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	: Professional Elective -5 (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 1. Basic concepts of knowledge of composites and its applications. 2. Types and common manufacturing techniques of composites. 3. Basic principles effect of operating parametersin selection of composites 4. 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 fundamentals, classification, and constituents of composite materials including matrix and reinforcement.
2. Identify different reinforcement types and their role in improving composite properties.
3. Describe manufacturing techniques of polymer, metal, and ceramic matrix composites.
4. Apply laminate theory, rule of mixtures, and process selection criteria in composite design.
5. Evaluate composites using non-destructive testing methods such as ultrasonic, X-ray, and thermography.
6. Analyze synthesis, fabrication, surface modification, and applications of graphene-based polymer composites.

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:	9

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 4:	9

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.

LIST OF EXPERIMENTS:

1. Study different types of composites and reinforcements (glass fiber, Kevlar, carbon fiber, SiC etc.) and classify them as PMC, MMC, or CMC.
2. Prepare a simple polymer matrix composite using hand lay-up technique and analyze matrix–reinforcement role.
3. Study moulding techniques such as compression moulding or resin transfer moulding for thermoset composites.
4. Demonstrate sheet moulding/extrusion/thermoforming or injection moulding process for thermoplastic composites.

5. Calculate composite density, strength, and modulus using rule of mixtures and study symmetry and balance in laminates.
6. Perform visual inspection, tap testing, or ultrasonic testing to detect defects in composite laminates.
7. Prepare graphene reinforced polymer composite using solution mixing or melt blending method.
8. Evaluate process selection based on cost, performance, size, and production rate; compare different manufacturing routes.

References:

1. Mallick, P. K. – Fiber-Reinforced Composites: Materials, Manufacturing and Design, CRC Press.
2. Hull, D. and Clyne, T. W. – An Introduction to Composite Materials, Cambridge University Press.
3. Chawla, K. K. – Composite Materials: Science and Engineering, Springer.
4. Gibson, R. F. – Principles of Composite Material Mechanics, CRC Press.
5. Campbell, F. C. – Manufacturing Processes for Advanced Composites, Elsevier.
6. Agarwal, B. D., Broutman, L. J. and Chandrashekhara, K. – Analysis and Performance of Fiber Composites, Wiley.
7. Callister, W. D. and Rethwisch, D. G. – Materials Science and Engineering: An Introduction, Wiley.
8. Chung, D. D. L. – Composite Materials: Science and Applications, Springer.
9. Rafiee, M. A. and Koratkar, N. – Graphene-Based Polymer Nanocomposites, Elsevier.
10. Kim, H. and Abdala, A. A. – Graphene Polymer Nanocomposites, Royal Society of Chemistry.

ECH-703: ENERGY STORAGE MATERIALS	
Course Category	: Professional Elective-7 (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 1. Emerging energy generation sources Types and common manufacturing techniques of composites. 2. Basic principles of storing and energy supply without any interruption 3. 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.

UNIT I:	9

INTRODUCTION: 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.

List of Experiments:

1. Study time-scale, applications, and efficiency using case data.
2. Evaluate charging–discharging characteristics and energy demand profile.
3. Calculate thermal efficiency and heat gain.
4. Charging and discharging analysis of PCM-based heat storage.
5. Evaluate heat storage capacity and energy efficiency.
6. Study hydrogen generation or storage concept (simulation/demo based).
7. Measurement of capacitance, charging/discharging curves.
8. Study working principle of SMES system using simulation/model.

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)

ECH-903: MATERIALS FOR SUSTAINABLE ENGINEERING	
Course Category	: Professional 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 1. Electrochemical energy and fuel cells. 2. Basic principles of batteries working 3. 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.
2. Describe the working principle of batteries.
3. Concept of supercapacitor as a novel system.
4. Explain the purpose and significance of fuel cell and its material.
5. Understand about design of batteries and their future perspective.

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

ECH-201: CHEMICAL EQUIPMENT DESIGN

Course Category	: Professional Elective-II (PE-2)
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 1. Fundamental principles of equipment design, including material selection, mechanical design, and fabrication methods. 2. Comprehensive understanding of various equipment types, their different configurations, and operating conditions. 3. Design and analyze various process equipment, including pressure vessels, heat exchangers, reactors, distillation columns, and other separation equipment.
Course Outcome	: At the end of the course the students will be able to:

1. Apply overall design principles, flow sheet development, and economic analysis for optimal chemical process design.
2. Evaluate plant safety, ethics, HAZOP, fault-tree analysis, and plant layout considerations.
3. Develop process design databases, flow diagrams, and preliminary equipment specifications.
4. Design and analyze heat transfer equipment such as double pipe and shell-and-tube heat exchangers.
5. Select and design separation units and reactors based on process requirements and catalyst performance.
6. Perform mechanical design of process equipment including cylindrical and spherical pressure vessels.

UNIT I	9

Introduction: Overall design considerations-Process design development, Flow sheet development, profitability analysis of investments, Optimum Design. Practical considerations in design. Engineering ethics in design.

General design considerations: Health and safety hazards-source of exposure, exposure evaluation, control of exposure hazards, fire and explosion hazards and safety regulations. Loss prevention-HAZOP study, fault-tree analysis, safety indexes and audits. Plant location and layout.

UNIT 2	9

Process design development: Development of design database, process creation, design and flow diagrams, Equipment design specifications, Preliminary design with a specific example. **Heat transfer equipment design:** Basic theory of heat transfer in exchangers, determination of heat transfer coefficients and pressure drop in heat exchangers, selection of heat exchange equipment, design of key heat exchangers (double pipe and shell & tube exchangers).

UNIT 3: MEMBRANE PROCESSES	9

Separation equipment design: Selection of suitable separation processes, separation by distillation, absorption & stripping and filtration.

Reactor design: Reactor principles, performance. Reactor and catalyst equipment- Selection of Catalyst, Types of Reactors, Selection of Reactors and Design of Reactor Systems

UNIT 4:	9
Mechanical design of process equipment: Design of Cylindrical and Spherical Vessels under internal pressure, heads and closures and tall vessels.	
List of Experiments: 1. Preparation and analysis of process flow sheet (PFD) and P&ID for a selected chemical process**.** 2. Perform profitability analysis and optimum design calculations for a small-scale chemical plant case study. 3. Conduct a HAZOP study / Fault Tree Analysis for hazard identification and loss prevention. 4. Preliminary design calculation of a Double Pipe Heat Exchanger (heat duty, LMTD, area). 5. Basic design of Shell & Tube Heat Exchanger including heat transfer coefficient and pressure drop estimation. 6. Selection and design calculations for separation equipment (distillation column / absorber / filtration unit). 7. Reactor design exercise: Performance evaluation and reactor type selection for a given reaction system. 8. Mechanical design of cylindrical or spherical pressure vessels under internal pressure (thickness, heads, closures).	
References 1. Plant Design and Economics for Chemical Engineers, Peters. M. S. and Timmerhaus, K.D., 5th Edition, McGraw Hill, (UNIT-I to III) 2. Introduction to Chemical Equipment Design, Mechanical aspects, B.C.Battacharyya, CBS Publishers and Distributors, (UNIT-IV). 3. Process Plant Design, Backhurst J.R. and Harker.J.H. Heineman, Educational Books 4. Chemical Engineering, Vol-6, Coulson J.M., Richardson J.F. and Sinnott, R.K., Pergamon press. 5. Process Equipment Design, Joshi, M.V. and Mahajani V.V, Macmilan India Ltd. 6. Coulson & Richardson's Chemical Engineering, Volume:2, J.F. Richardson, J. H. Harker and J. R. Backhurst, 4th edition, Elsevier.	

ECH-401: PRINCIPLES OF SAFETY MANAGEMENT	
Course Category	: Professional Elective-IV (PE-4)
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 1. fundamental principles and practices of safety management in various organizational settings 2. Skills necessary to identify, evaluate, and control workplace hazards, promote a culture of safety, and ensure compliance with safety regulations and standards

	3. Design and implement effective safety programs, analyze incidents, and apply risk management techniques to prevent accidents and occupational injuries.
Course Outcome	: At the end of the course the students will be able to:

1. Explain fundamental concepts, goals, and organizational roles in industrial safety management.
2. Apply accident prevention methods including engineering, education, enforcement, and work permit systems.
3. Identify appropriate PPEs and implement safety training, communication, and housekeeping practices.
4. Evaluate safety performance using inspection methods, safety audits, and accident cost analysis.
5. Conduct job safety analysis (JSA), safety surveys, and workplace risk assessment techniques.
6. Analyze and investigate accidents using systematic tools and accident analysis methodologies.

UNIT I	9

Introduction-Safety -Goals of safety engineering. Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. History of safety movement. Theories of accident causation. Safety organization-objectives, types, functions, Role of management, supervisors, workmen, unions, government and voluntary agencies in safety. Safety policy. Safety Officer-responsibilities, authority. Safety committee-need, types, advantages

UNIT 2	9

Accident prevention Methods- Engineering, Education and Enforcement. Safety Education & Training -Importance, Various training methods, Effectiveness of training, Behaviour oriented training. Communication- purpose, barrier to communication. Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping. Work permit system- objectives, hot work and cold work permits. Typical industrial models and methodology. Entry into confined spaces.

UNIT 3:	9

Personal protection in the work environment, Types of PPEs, Personal protective equipment-respiratory and non-respiratory equipment. Standards related to PPEs. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate. Cost of accidents-Computation of Costs- Utility of Cost data. Plant safety inspection, types, inspection procedure. Safety sampling techniques. Job safety analysis (JSA), Safety surveys, and Safety audits. Safety Inventory Technique.

UNIT 4:	9

Accident investigation –Why? When? Where? Who? & How? Basics- Man- Environment & Systems. Process of Investigation –Tools-Data Collection-Handling witnesses- Case study. Accident analysis –Analytical Techniques-System Safety-Change Analysis-MORT-Multi Events Sequencing-TOR.

References

1. Krishnan, N.V. Safety management in Industry. Jaico Publishing House, New Delhi.(1997).
2. John V. Grimaldi and Rollin H.Simonds Safety management. All India Traveller Book Seller,
1. Delhi. (1989). 3. Ronald P. Blake Industrial safety. Prentice Hall, New Delhi. (1973).

3. Ted S. Ferry Modern accident investigation and analysis, John Wiley & Sons, Hoboken, N.J.
2. (1988).
4. Alan Waring Safety management system. Chapman & Hall, England. (1996).
3. 6. National Safety Council Accident prevention manual for industrial operations. Chicago.
4. (1982).

ECH-601: CHEMICAL PROCESS SAFETY	
Course Category	: Professional Elective-VI (PE-6)
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 1. Fundamental principles of chemical process safety. 2. Risk analysis, hazard identification, and accident prevention techniques in chemical industries. 3. Safety standards, codes, and practices applicable to chemical processes.
Course Outcome	: At the end of the course the students will be able to:

1. Apply safety principles in chemical process plant design and equipment specification.
2. Analyze PFDs, P&IDs, and reactor operations for safe design, start-up, and shutdown.
3. Interpret MSDS and chemical properties to ensure safe plant operation.
4. Evaluate safe storage, handling, and transportation of hazardous chemicals and gases.
5. Assess chemical reaction hazards including runaway reactions, detonations, and explosions.
6. Recommend safety control measures such as relief systems, monitoring, and hazardous area classification.

UNIT I	9

Safety in the design of chemical process plants :-Design principles – Process design development – types of designs, feasibility survey, preliminary design, flow diagrams, piping and instrumentation diagram, batch versus continuous operation, factors in equipment scale up and design, equipment specifications - reliability and safety in designing – inherent safety – engineered safety - safety during start up and shutdown – safety checks in the design of the equipments – reactor safety - safety in erection and commissioning of chemical plants - nondestructive testing methods – pressure and leak testing – emergency safety devices – scrubbers and flares – new concepts in safety design and operation- Pressure vessel testing standards– Inspection techniques for boilers and reaction vessels.

UNIT 2	9

Safety in the operation of chemical process plants: - Properties of chemicals – Material Safety Data Sheets – the various properties and formats used – methods available for property determination. Operational activities and hazards –standards operating procedures – safe operation of pumps, compressors, heaters, column, reactors, pressure vessels, storage vessels, piping systems – effects of pressure, temperature, flow rate and humidity on operations – corrosion and control measures-

condition monitoring - control valves – safety valves – pressure reducing valves, drains, bypass valves, inert gases. Chemical splashes, eye irrigation and automatic showers.	
UNIT 3:	9
Safety in the storage and handling of chemicals and gases:-Types of storage-general considerations for storage layouts- atmospheric venting, pressure and temperature relief – relief valve sizing calculations - storage and handling of hazardous chemicals and industrial gases, safe disposal methods, reaction with other chemicals, hazards during transportation – pipe line transport – safety in chemical laboratories. Safety provisions like level and flow indicators – alarms, trips – protection of stills, columns and towers from lightening – colour coding for pipe lines and cylinders.	
UNIT 4:	9
Chemical reaction hazards: Hazardous inorganic and organic reactions and processes, Reactivity as a process hazard, Detonations, Deflagrations, and Runaways, Assessment and Testing strategies, Self – heating hazards of solids, Explosive potential of chemicals, Structural groups and instability of chemicals, Thermochemical screening, Case studies. Stability and sensitivity tests, Classification of materials with explosive potential, Hazard prediction by thermodynamic calculations, Prevention and control of explosions and detonations – diluting a release, purging and inserting, venting, explosion relief, flame arrestors, explosion suppression, Classification of hazardous areas.	
References 1. Ralph King and Ron Hirst. King's safety in the process industries. Arnold, London. (1998). 2. Industrial Environment and its Evolution and Control, NIOSH publication. (1973). 3. National Safety Council. Accident prevention manual for industrial operations. Chicago. (1982). 4. Lewis, Richard. J., Sr. Sax's dangerous properties of materials. (Ninth edition). Van Nostrand Reinhold, New York. (1996).	

ECH-801: FIRE ENGINEERING FUNDAMENTALS	
Course Category	: Professional Elective -VIII (PE-8)
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 1. Fundamental principles of fire engineering 2. About fire behavior, fire prevention techniques, fire safety regulations, and design of fire protection systems. 3. Engineering principles in mitigating fire risks and ensuring the safety of people, property, and the environment.
Course Outcome	: At the end of the course the students will be able to:

1. Explain the theory of fire chemistry and the different kinds of combustion and their characteristics
2. Summarize the characteristics of diffusion and premixed flame
3. Explain the theory of heat transfer mechanism in compartment fires.
4. Describe the use and operation of fire service equipment, machineries and accessories.
5. Calculate the water requirement and the pump capacity for firefighting.
6. Recognize the basic fire ground operations.

UNIT I	9

Introduction- temperature, heat, specific heat, flash point, fire point, ignition, combustion; Ignition-pilot ignition, spontaneous ignition, ignition sources; Types of combustion-rapid, spontaneous, physical explosion, chemical explosion; Smoldering combustion; Product of combustion harmful to human-flame, heat, smoke, fire gases; Special kinds of combustion- Flash fire, Pool fire, Deep seated fire, Spillover, Boil over, Dust explosion, BLEVE, VCE; Classification of fire based on material
Development of enclosure fire in terms of temperature-incipient, smoldering, flame and heat stages; factors influencing fire development in an enclosure;
Diffusion flames-Zones of combustion, characteristics of diffusion flames , laminar and turbulent jet flames, flame from natural fires, buoyant plume; Premixed flames-structure, limits of flammability, burning velocity, explosion and expansion ratios, deflagration and detonation, characteristics of premixed flame; Spread of flames over liquid and solid surfaces.

UNIT 2	9

Heat transfer in compartment fires- Fuels, Calorific value, fire load, heat release rate and factors controlling heat release rate, basic heat transfer equations, Convective heat transfer in fire, Radiative heat transfer in fire; Radiation from hot gases and non-luminous flames; Radiation from luminous flames and hot smoky gases.
Fire plumes and flame heights- flame characteristics, mean flame height, flame height correlations, turbulent fire plume characteristics, ideal plume, line plume, bounded plume, ceiling jets, response of ceiling mounted fire detectors, interaction between sprinkler spray and the fire plume.

UNIT 3:	9

Use, operation and maintenance of fire service equipments and accessories- Suction and delivery Hose, Hose reel, Hose fittings-coupling, adapters, branches, branch holders, radial branches, collecting heads, stand pipe, monitors, hydrants; Introduction to fire fighting vehicles and appliances-crash tenders, rescue tenders, hose laying tenders, control vans, hydraulic platforms; Ladders-extension ladders, hook ladder, turntable ladders, snorkel; Fire pumps and primers; Uses and maintenance of small gear and miscellaneous equipments used during firefighting; Lamps and lighting sets; Ropes and Lines- wire and rope lines used in fire service, use and testing of lines, knots, bends and hitches and general rope work.

UNIT 4:	9

Fire Hydraulics- path and range of fire stream, types of nozzles and calculation of discharge capacity, nozzle reaction; Pressure loss or gain because of elevation; back pressure; Flow in pipes and fire hoses-hydraulic and energy grade lines, friction loss in pipes, fire hoses and fixtures, parallel and series connection of fire hoses, branching lines; Water relay techniques; Estimation of fire protection water requirements, pump capacity and other parameters relating to fire hydraulics.

Fire ground operations - preplanning, action on arrival and control, methods of rescue, methods of entry. Personnel safety. Control procedure and use of other safety equipment. Ventilation and salvage operations.

References

1. Ron Hirst Underdowns practical fire precautions, Gower publishing company Ltd., England. (1989).
2. Gupta, R.S. A Hand book of fire technology (2nd edn.). Universities Press Pvt. Ltd., New Delhi.(2010).
3. Andrew L Simon, Fire hydraulics Prentice-Hall Inc., USA. (1983).
5. Bjorn Karlsson and James G. Quintiere, Enclosure Fire Dynamics, CRC Press, USA (2000).
4. Dougal Drysdale An Introduction to Fire Dynamics, (2nd edn.), John Wiley & Sons Ltd., England. (1999)
6. Jain V.K. Fire safety in buildings (2nd edn.). New Age International (P) Ltd., New Delhi. (2010).

ECH-202 BASICS OF MACHINE LEARNING (ML) FOR CHEMICAL ENGINEERING		
Course category	:	**Professional Elective – II (PE-2)**
Pre-requisite Subject	:	Computer Programming (Python, MATLAB), Mathematics
Contact hours/week	:	Lecture: 3, Tutorial: 0 , Practical: 2
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through home assignments, quizzes, practical work, record, and one minor test, attendance, one major theory.
Course Objectives	:	Understanding of the basic principles and concepts of Machine Learning, This course will introduce students to learn machine learning (ML) and its applications across various areas of chemical engineering. Students will also be introduced to various ML Python libraries and all modules will involve hands-on case studies.
Course Outcomes	:	1. To understand the need for machine learning for various problem solving. 2. To understand a wide variety of learning algorithms and how to evaluate models generated from data. 3. To understand the latest trends in machine learning. 4. To design appropriate machine learning algorithms and apply the algorithms to a real-world problems 5. To optimize the models learned and report on the expected accuracy that can be achieved by applying the models

Topics Covered	
UNIT-I: **Introduction**	9
Machine Learning - Machine learning introduction, Categories of ML, Difference between AI and machine learning Machine Learning and deep learning?, Supervised, Unsupervised, Reinforcement, Semi Supervised, Regression, Classification, Gradient Descent for single variable & Multiple Variables, Cost Function	
UNIT-II: Supervised Learning	9

Introduction to SL, linear classification, non-linear classification, linear, regression, Logistic regression, loss function, regularization, gradient algorithms, features, Support Vector Regression, Support Vector Classification, Classification –Random forest, Decision tree	
UNIT-III: Unsupervised learning	9
Introduction to USL, what is Clustering & its Use Cases, K- means Clustering, K-nearest Neighbors Hierarchical clustering, High-dimensional clustering, Dimension Reduction-Principal Component Analysis (PCA).	
UNIT-IV: Deep Learning	9
Artificial Neural Networks – ANN structure, Feed Forward Neural network, Back Propagation, optimization algorithms for training deep networks, normalization, Convolutional Neural Network (CNN), CNN architectures (AlexNet, VGG, ResNet, GoogleNet), Recurrent Neural Network (RNN), Long Short Term Memory (LSTM) Network	

List of Experiments:

1. Implement a python program to perform linear regressions for a dataset that prevails in csv format
2. Implement a python program to perform logistic regression
3. Write a program to implement k-Nearest Neighbour algorithm to classify any dataset, Assume that K=3.
4. Assuming a set of data (Flower Recognition) that need to be classified, use a decision tree model to perform this task.
5. Assuming a set of data (medical data) that need to be classified, use a Support Vector Machine model to perform this task.

Books & References

1. Introduction to Machine Learning with Python: A Guide for Data Scientists by Andreas Muller
2. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems by Aurelien Geron
3. Mathematics for Machine Learning by by Marc Peter Deisenroth , A. Aldo Faisal , Cheng Soon Ong
4. Machine Learning an algorithmic perspective by Sthephen Marsland, CRC Press
5. Machine Learning in Action by Peter Harrington, Manning Shelter Island
6. Tom M. Mitchell, ―Machine Learning, McGraw-Hill Education (India) Private Limited, 2013.

ECH-402	**ARTIFICIAL NEURAL NETWORKS AND DEEP LEARNING**	
Course category	:	Professional Elective -IV (PE-IV)
Pre-requisite Subject	:	Computer Programming (Python, MATLAB), Mathematics
Contact hours/week	:	Lecture: 3, Tutorial: 0 , Practical: 2
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through home assignments, quizzes, practical work, record, and one minor test, attendance, one major theory.
Course Objectives	:	Understanding of the basic principles and concepts of Artificial Neural Networks and Deep Learning. This course will introduce students to learn ANN and DL and its applications across various

		areas of chemical engineering. Students will also be introduced to various ML Python libraries and all modules will involve hands-on case studies.
Course Outcomes	:	1. Understand the basics principles of Artificial Neural Networks and Deep Learning 2. Understand the uses of various ML Python libraries 3. Apply structured thinking to unstructured problems. 4. Understand a very broad collection of machine learning algorithms and problems 5. Hands-on ANN/DL in chemical engineering case studies

Topics Covered	
UNIT-I: **Introduction**	9
Machine Learning - Machine learning introduction, Categories of ML, History of ML Difference between AI and machine learning Machine Learning and deep learning, Issues in Machine Learning and Data Science Vs Machine Learning; Supervised, Unsupervised, Reinforcement, Semi Supervised, Regression, Classification, Gradient Descent for single variable & Multiple Variables	
UNIT-II: Supervised Learning, Unsupervised Learning and R**einforcement Learning**	9
Introduction to SL, linear classification, non-linear classification, linear, regression, Logistic regression, loss function, regularization, gradient algorithms, features, Support Vector Regression, Support Vector Classification, Classification –Random forest, Decision tree, Introduction to USL, what is Clustering & its Use Cases, K- means Clustering, Hierarchical clustering, High-dimensional clustering, Dimension Reduction- Principal Component Analysis (PCA), K-nearest Neighbors. Introduction to Reinforcement Learning , Learning Task, Learning Models for Reinforcement	
UNIT-III: Artificial Neural Networks	9
Introduction of Artificial Neural Networks, ANN structure, ANN terminologies, Activation function, weight and bias, Perceptron's, Multilayer perceptron, Gradient descent and the Delta rule, Multilayer networks, Generalization, Fundamental model of ANN, normalization, Feed Forward Neural network, Back Propagation, Derivation of Back propagation Algorithm, application of ANN, ANN Project with MATLAB, Recurrent Neural Network (RNN), Radial Basic Function Network.	
UNIT-IV: Convolutional Neural Network (CNN)	9
Introduction, concept of convolutional neural network , Types of layers – (Convolutional Layers, Activation function , pooling , kernel filters, stride, padding, fully connected Layer), Concept of Convolution (1D and 2D) layers, Training of network, CNN architectures (AlexNet, LeNet, VGG net, ResNet, GoogleNet, ZFNet), optimization algorithms for training deep networks, Case study of CNN, Long Short Term Memory (LSTM) Network	

List of Experiments:

1. Prediction of Wine type using Deep Learning
2. Flower Recognition Using Convolutional Neural Network
3. Heart Disease Prediction using ANN
4. Classification a set of data (Cat & Dog) using Convolutional Neural Network in Python
5. Rainfall Prediction using Machine Learning in Python
6. Handwritten Digit Recognition using Neural Network

7. Calories Burnt Prediction using Machine Learning
Books & References 1. Introduction to Machine Learning with Python: A Guide for Data Scientists by Andreas Muller 2. Deep learning with Python by Francois Chollet, Manning Publishers 3. Machine learning and deep learning using Python and Tensorflow by V.R. Konasani, S. Kadre, MC Graw Hill publisher 4. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems by by Aurelien Geron 5. Mathematics for Machine Learning by by Marc Peter Deisenroth , A. Aldo Faisal , Cheng Soon Ong **6.** Machine Learning an algorithmic perspective by Sthephen Marsland, CRC Press **7.** Machine Learning in Action by Peter Harrington, Manning Shelter Island.

ECH-602	**Programming Basics of Machine Learning**	
Course category	:	Professional Elective -VI (PE-6)
Pre-requisite Subject	:	Basic of Computer Program, Mathematics
Contact hours/week	:	Lecture: 3, Tutorial: 0 , Practical: 2
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through home assignments, quizzes, practical work, record, and one minor test, attendance, one major theory.
Course Objectives	:	Understanding of the basic programming principles of Machine Learning and concepts of Machine Learning, This course will also be introduced to various ML Python libraries and basic concept of Optimization & Probability Theory in ML.
Course Outcomes	:	1. To read and write simple Python programs 2. To develop Python programs with conditionals and loops, 3. To understand the Python library for machine learning. 4. To design appropriate machine learning algorithms and apply the algorithms to a real-world problems 5. To understand basic concept of Optimization & Probability Theory in ML

Topics Covered	
UNIT-I: **Introduction**	9
Introduction: The Programming Cycle for Python, Python IDE, Interacting with Python Programs, Elements of Python, Type Conversion. Basics: Expressions, Assignment Statement, Arithmetic Operators, Operator Precedence, Boolean Expression.	
UNIT-II: Basics of Python programming	9
Conditionals: Conditional statement in Python (if-else statement, its working and execution), Nested-if statement and Elif statement in Python, Expression Evaluation & Float Representation. Loops: Purpose and working of loops, While loop including its working, For Loop, Nested Loops, Break and Continue. **Function:** Parts of A Function, Execution of A Function, Keyword and Default Arguments, Scope Rules.	

Strings: Length of the string and perform Concatenation and Repeat operations in it. Indexing and Slicing of Strings. Python Data Structure : Tuples , Unpacking Sequences , Lists , Mutable Sequences , List Comprehension , Sets , Dictionaries Higher Order Functions: Treat functions as first class Objects , Lambda Expressions **File I/O** : File input and output operations in Python Programming Search : Simple Search and Estimating Search Time , Binary Search and Estimating Binary Search Time Sorting & Merging: Selection Sort , Merge List , Merge Sort , Higher Order Sort	
UNIT-III: Python Packages	9
NumPy: Python libraries for data analysis, history of NumPy, importance of NumPy, features of NumPy, Array, installing NumPy module, creation of NumPy arrays, data types and string operations, indexing, slicing and advanced indexing, arithmetic operators, array manipulation functions, joining and splitting of arrays, sorting and searching elements of nth array, insert and delete elements of nth array, basic statistics with NumPy unique function, matrix multiplication using dot function. **Pandas:** Data frame, pandas data frame function, pivoting data frame , sorting, missing data, combining data frames, summarizing data, transform function in python, re-indexing in pandas data frame, time series data structures **Matplotlib:** importance of data visualization, plotting time series data, seaborn/ matplotlib library, correlation matrix plot, various type of plots, visualizing pair wise relationship, box plot in seaborn, regplot() vs impot() **Sckit –learn:** Introduction of Scikit learn, Scikit learn library, Algorithms in various ML class such as Regression, Classification, Clustering , Preprocessing, Dimension Reduction	
UNIT-IV: Optimization & Probability Theory	9
Optimization: Introduction to Optimization, Numerical Optimization in Machine Learning, Gradient Descent and Introduction of Constrained and Unconstrained Optimization: Random search methods, penalty function method, Optimization Using Gradient Descent, Constrained Optimization and Lagrange Multipliers, Maxima and Minima, Convex and Non-Convex, Convex Optimization **Probability Theory:** Construction of a Probability Space, Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem, Gaussian Distribution, Conditional Probability, Joint Probability Distribution and covariance, Multivariate, Expectation and variance, Conjugacy and the Exponential Family, Change of Variables/Inverse Transform.	
List of Experiments 1. To understand Python syntax, variables, operators, and type conversion. 2. To implement decision making and iterative control structures. 3. To develop user-defined functions and work with strings. 4. To explore built-in data structures and file I/O. 5. To implement searching and sorting techniques. 6. To perform numerical computing using NumPy. 7. To analyze and visualize datasets. 8. To introduce Scikit-learn models and optimization concepts.	

Books & References

1. Introduction to Machine Learning with Python: A Guide for Data Scientists by Andreas Muller
2. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems by by Aurelien Geron
3. Mathematics for Machine Learning by by Marc Peter Deisenroth , A. Aldo Faisal , Cheng Soon Ong
4. Machine Learning an algorithmic perspective by Sthephen Marsland, CRC Press
5. Machine Learning in Action by Peter Harrington, Manning Shelter Island
6. Tom M. Mitchell, ―Machine Learning, McGraw-Hill Education (India) Private Limited, 2013.

ECH-608	**COMPUTATIONAL TECHNIQUES FOR MACHINE LEARNING (ML)**	
Course category	:	Professional Elective-VII (PE-8)
Pre-requisite Subject	:	Mathematics
Contact hours/week	:	Lecture: 3, Tutorial: 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through home assignments, quizzes, practical work, record, and one minor test, attendance, one major theory.
Course Objectives	:	In order to develop new algorithms of machine/deep learning, it is necessary to have knowledge of all such mathematical concepts. It provides the theoretical framework, necessary for understanding and developing of AI and ML algorithms system effectively.
Course Outcomes	:	1. To understand the need of mathematics for machine learning. 2. To understand a background of learning algorithms of ML. 3. To optimise the machine learning algorithms of current issues in the world. 4. To design appropriate machine learning algorithms and apply the algorithms to a real-world problems

Topics Covered	
UNIT-I: **Vector & Matrices**	9
Norm of a vector, Sum and difference of vectors, Distance between vectors, Multiplying a vector by a scalar, The dot product, Geometric Dot Product, Multiplying a matrix by a vector, Basics of Matrix Special Matrices and Properties. Determinant and Trace, Linear transformations Eigen values and Eigenvectors, Cholesky Decomposition, Eigende composition and Diagonalization, Singular Value Decomposition	
UNIT-II: Partial Differentiation	9
Differentiation of Univariate Functions, Partial Differentiation and Gradients, Gradients of Vector-Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients, Back propagation and Automatic Differentiation, Higher-Order Derivatives, Linearization and Multivariate Taylor Series	
UNIT-III: Probability and Distributions	9
Construction of a Probability Space, Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem, Gaussian Distribution, Conditional Probability, Joint	

Probability Distribution and covariance, Multivariate, Expectation and variance, Conjugacy and the Exponential Family, Change of Variables/Inverse Transform.	
UNIT-IV: Optimization	9
Introduction to Optimization, Numerical Optimization in Machine Learning, Gradient Descent and Introduction of Constrained and Unconstrained Optimization: Random search methods, penalty function method, Optimization Using Gradient Descent, Constrained Optimization and Lagrange Multipliers, Maxima and Minima, Convex and Non-Convex, Convex Optimization	

Books & References

1. Mathematics for Machine Learning by Marc Peter Deisenroth , A. Aldo Faisal , Cheng Soon Ong
2. Machine Learning Mathematics: Study Deep Learning Through Data Science. How to Build Artificial Intelligence Through Concepts of Statistics, Algorithms, Analysis and Data Mining by By: Samuel Hack
3. Mathematics and Programming for Machine Learning with R: From the Ground Up by by William B. Claster, CRC press
4. Unraveling the Mathematics of Machine Learning and Deep Learning Algorithms :
5. by Pradeep Tripathi
6. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems by by Aurelien Geron
7. Machine Learning an algorithmic perspective by Sthephen Marsland, CRC Press

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ECH-203: REACTIVE SEPARATION TECHNIQUES	
Course Category	: Professional Elective -I (PE-1)
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 1. Newer separation processes, like, membrane based techniques, chromatographic separation, super critical fluid extraction, etc., 2. Basic concepts of various separation processes, and its applications. 3. Fundamentals as well as the recent developments of different processes as well as their industrial applications.
Course Outcome	: At the end of the course the students will be able to:

1. Build advanced concepts of separation techniques used in chemical industries.
2. Understand the principles and functioning advanced separation techniques.
3. Utilize the advanced separation technique in problem solving where conventional techniques are not fruitful and require replacement.
4. Understand the applications of advanced separation techniques as per industrial requirement.

5. Recognize the selection criteria between advanced separation techniques and conventional separation techniques.

UNIT I:	9
Super Critical Extraction: Working Principal, Advantage & Disadvantages of supercritical solvents over conventional liquid solvents, Advantage & Disadvantages of supercritical extraction over liquid-liquid extraction, Decaffeination, ROSE process, Commercial applications of supercritical extraction.	
UNIT 2:	9
Reactive & Catalytic Distillation: Concept, Advantage & Disadvantages, BALE & KATMAX packing Manufacturing of MTBE and ETBE and it's comparision with conventional techniques.	
UNIT 3:	9
Pressure Swing Distillation: Concept & Working, Advantage & Disadvantages of PSD over azeotropic and Extractive Distillation, Applications. **Pressure Swing Adsorption:** Concept & Working, Advantages & Disadvantages of PSA over cryogenic distillation, four step PSA, six step PSA, Purification of hydrogen, oxygen, Nitrogen & other commercial applications of PSA.	
UNIT 4:	9
Membrane Reactor: Concept & working, Various modules of membrane used for membrane reactor, Advantages & Disadvantages, applications under research	

LIST OF EXPERIMENTS

1. Perform separation techniques using reactive distillation**.**
2. Perform separation using membrane modules.
3. Perform separation techniques using supercritical extraction.
4. Preparation of membrane modules for reverse osmosis.
5. Perform separation techniques using short path distillation.

Design based Problems (DP)/Open Ended Problem:

Open Ended projects in Advanced analytical techniques may include:

1. Review chart of application of advanced separation techniques in process industries.
2. Fabrication of reactive catayltic distillation unit.
3. Fabrication of short path distillation.
4. Fabrication and perfomance evaluation of different types of filtration membranes,
5. Fabrication of membrane module

References

1. Kaushik Nath, "Membrane separation Processes", PHI pvt. Ltd., 2008
2. S.B. Thakore & B.I Bhatt, Introduction to process Engineering & Design" Tata McGraw-Hill Ltd.,2007
3. R.H Perry and D. Green, "Perry Chemical Engineers Handbook" 7th Edition
4. Ullman's Encyclopedia of Industrial Chemistry.
5. Kirk & Othmer,"Encyclopedia of Chemical Engineering".
6. M. Mukhopadhyay, "Natural Extracts using supercritical carbon dioxide"

ECH-403: Advanced Physico-chemical processes for wastewater treatment	
Course Category	: Professional Elective-IV (PE-4)
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 1. Basic concepts of various waste water treatment processes. 2. Fundamentals as well as the recent developments of different processes as well as their industrial applications. 3. Basic principles, operating parameters, types of membrane used, flux equation, transport mechanism. 4. Applications of advance separation processes through case study.
Course Outcome	: At the end of the course the students will be able to:

1. Understand the basic principles for different treatment processes and its applications.
2. Learn the basics of membrane and various membrane modules.
3. Evaluate the selection criteria of appropriate physico-chemical treatment technologies based on wastewater characteristics, design parameters, and regulatory discharge standards.
4. Identify established membrane separation processes and learn concepts of upcoming membrane separation processes.
5. Design and perform mass balance calculations, reactor sizing, and operational parameter estimation for advanced wastewater treatment units.
6. Assess process efficiency, operational challenges, cost implications, and environmental sustainability aspects of advanced physico-chemical treatment systems.

UNIT I:	9
Introduction to Water Pollution and Control, Pre-treatment & Physical treatment: Flow equalization & Aeration; Pre-treatment & Physical treatment: Coagulation and Flocculation.	
UNIT 2:	9
Introduction, Setting and Sedimentation & Settling Chamber Design, Filtration & Filtration System Design; Wastewater treatment by Adsorption & Ion Exchange.	
UNIT 3:	9
Wastewater treatment by Membrane Based Technologies: Introduction, Reverse Osmosis: Introduction and definition, theory and design, different membrane modules, selected applications and economics. Ultra-filtration: Introduction and definition, theory and design, membrane module and process configuration, applications and economics. Micro filtration: Introduction and definition, theory of cross flow filtration, dead end micro filtration, and applications.	
UNIT 4:	9
Advanced Oxidation Processes: Introduction, Advanced Oxidation Processes: Fenton and catalytic treatment; Advanced Oxidation Processes: Photo-induced processes; Advanced Oxidation Processes: Sono- and Electro-chemical Treatment; Case studies on wastewater treatment in various process, chemical and allied industries.	
References	

1. Wilson & Sirkar, Membrane Handbook, Mc Grawhill, London, (2001)..
2. Nune and Peinemann, Membrane Technology in chemical industries, Wiley, New York, (2000).
3. Cheryan Munir, Ultra filtration Handbook, Technomic, New York, (1985)
4. Noble and Stern, Membrane separation and technology, principles and applications, Elsevier, (1995).
5. Baker R W, Membrane technology and applications, Wiley, New York, (2000).

ECH-603: Desalination and Cleaner Water Production with Membrane Technologies	
Course Category	: Professional Elective – VI (PE-6)
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 1. Basic concepts of desalination separation process and its applications. 2. Fundamentals and recent developments in desalination. 3. Basic principles, operating parameters, types of membrane used in desalination. 4. Applications of desalination in water production/purification.
Course Outcome	: At the end of the course the students will be able to:
1. Understand the basics of desalination 2. Understand the working and classification of desalination. 3. Understand the working and classification of desalination. 4. Evaluating the best suitable desalination process for water production/purification	
UNIT I:	9
Growing needs, and water stress; alternate water resources - wastewater and seawater purification; definition of sustainability; key areas of development for sustainable desalination; introduction of membrane science, engineering and applications	
UNIT 2:	9
Renewable energy powered desalination: Classification of desalination processes; introduction to solar desalination; potential processes for solar desalination; gain output ratio; performance ratio; environmental impacts of desalination, case studies.	
UNIT 3:	9
Introduction to emerging membrane distillation technology: Membrane distillation and its configurations; transfer process; ideal membrane characteristics; types of membranes; liquid entry pressure; limitations wetting, scaling, fouling; advantages of membrane distillation	
UNIT 4:	9

Cleaner water production/applications for industry, drinking water: Different treatment processes and their combination; produced water quality; selection of membrane technologies; target applications; relevant case studies.

List of Experiments:

1. To analyze raw, treated and desalinated water samples.
2. To demonstrate the principles of membrane separation.
3. To study renewable-energy powered desalination.
4. To calculate performance indicators.
5. To study emerging membrane distillation technology.
6. To evaluate membrane wetting resistance.
7. To examine operational limitations.
8. To design a cleaner water production process.

References

1. Caetano, A., de Pinho, M.N., Drioli, E., Muntau, H. (Eds.2012), Membrane Technology: Applications to Industrial Wastewater Treatment. ISBN-13: 978-0792332091, Publisher: Springer (30 November 1994)
2. Saji, Viswanathan S., Meroufel, Abdelkadar A., Sorour, Ahmad (Eds.2020), Corrosion and Fouling Control in Desalination Industry, ISBN 978-3-030-34284-5
3. Richard W. Baker, Membrane technology and applications (2012). US: Willey. ISBN: 0 07 135440
4. Nikolay V., Desalination Engineering: Planning and Design. McGraw-Hill, 1 Edition(2012)
5. Lior N., Advances in Water Desalination. US: Wiley, 1 Edition(2013)

ECH-805: Interfacial Engineering	
Course Category	: Professional Elective – VI (PE-6)
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 1. Fundamental concepts of interfacial phenomena. 2. Surface and interfacial tension, wetting behavior, thin film formation. 3. Adsorption mechanisms at interfaces, surfactant behavior, monolayer formation, and adsorption isotherm models relevant to colloidal. 4. Interfacial transport processes, rheological behavior, Marangoni effects, and the stability of thin liquid films.
Course Outcome	: At the end of the course the students will be able to:

1. Explain the fundamental concepts of interfacial engineering and their significance in scientific and industrial applications.

2. Analyze surface and interfacial tension phenomena and interpret curvature and wetting behavior at interfaces.
3. Evaluate experimental methods for characterization of interfaces and techniques for studying colloidal dispersions and thin film deposition.
4. Apply adsorption theories and isotherm models to describe surfactant behavior and adsorption mechanisms at fluid–fluid and fluid–solid interfaces.
5. Assess interfacial transport phenomena and rheological behavior, and stability of thin liquid films.
6. Design and evaluate interfacial engineering applications in advanced materials processing, catalysis, nanomaterials synthesis, crystallization, and electronic/ceramic product development.

UNIT I:	9

Introduction to the engineering of interfaces; Definitions of fluid-fluid and fluid-solid interfaces; Occurrence of interfaces in science and engineering; Overview of industrial applications of various interfacial phenomena; Colloidal materials; Properties of colloidal systems; Experimental characterization of colloidal dispersions.

UNIT 2:	9

Surface and interfacial tension; Theoretical methods for the calculation of surface and 05 interfacial tension; Experimental techniques for the determination of equilibrium and dynamic tension; Shape of the surfaces: curvature and radius of curvature; Young Laplace equation; Kelvin equation; Pendant and sessile drops; Adams-Bashforth equation; Characterization of fluid-solid interfaces; Contact angle and wetting phenomena;Young-Dupré equation; Measurement of equilibrium and dynamic contact angles; Deposition of thin films; Mechanism of film nucleation; Chemical vapor deposition, molecular beam epitaxy, sputtering and atomic layer deposition techniques; Applications of fluid-solid interfaces in crystallization, development of ceramic materials, catalysts, electronic products and nanomaterials.

UNIT 3:	9

Adsorption at fluid-fluid and fluid-solid interfaces; Adsorption of surfactants; Gibbs and Langmuir monolayers; Gibbs adsorption equation; Surface equation of state; Surface pressure isotherm; Langmuir-Blodgett films and their applications; Radiotracer and neutron reflection techniques for studying adsorption at fluid-fluid interfaces; Henry, Freundlich, Langmuir, Frumkin and Davies adsorption isotherms; Brunauer-Emmett Teller theory of adsorption; Adsorption hysteresis; Characterization of adsorption at fluid-solid interfaces by vacuum and nonvacuum techniques.

UNIT 4:	9

Interfacial rheology and transport processes; Surface shear viscosity; Surface dilatational viscosity; Boussinesq number; Interfacial tension gradient and Marangoni effect; Gibbs and Marangoni elasticity; Boussinesq Scriven model; Interfacial turbulence; Motion of drops in a liquid; Thin liquid films; Disjoining pressure and body-force models; Stability of thin liquid film; Black films.

References

1. Adamson, A. W. and Gast, A.P., Physical Chemistry of Surfaces, John Wiley, New York, 1997.
2. Ghosh, ., Colloid and Interface Science, PHI Learning Pvt. Ltd., New Delhi, 2009.
3. Hiemenz, P. C. and Rajagopalan, R., Principles of Colloid and Surface Chemistry, Marcel Dekker, New York, 1997.

4. Stokes, R. J. and Evans, D. F., Fundamentals of Interfacial Engineering, Wiley-VCH, New York, 1997.
5. Baszkin, A. and Norde, W., Physical Chemistry of Biological Interfaces, Marcel Dekker, New York, 2000.
6. Edwards, D.A., Brenner, H. and Wasan, D. T., Interfacial Transport Processes and Rheology, Butterworth Heinemann, Boston, 1990.
7. Hunter, R. J., Foundations of Colloid Science, Oxford University Press, New York, 2005.

Syllabus of Audit Courses

CONSTITUTION OF INDIA

Course Code: **:** **AUC 101** **Credits (0-0-0)**
Course Category **:** **Audit**
Pre-requisite Subject : NIL
Contact Hours/Week : 1/2 Lecture : , Tutorial : , Practical:
Number of Credits : 0 Credit

Course Assessment Methods: Continuous assessment through tutorials, attendance, home assignments, quizzes, practical, Tutorial class, viva voce and Minor tests and One Major Theory Examination.

Course Outcomes:

At the end of the course, learners should be able to
CO1- Student will Identify and explore the basic features and modalities about Indian constitution
CO2- Students will be able to differentiate and relate the functioning of Indian parliamentary system at the center and state level.
CO3- Student will be able to differentiate different aspects of Indian Legal System and its related bodies.

UNIT 1--Introduction and Basic Information about Indian Constitution: Historical Background of the Constituent Assembly, The Preamble of the Constitution, Fundamental Rights, Fundamental Duties, Directive Principles of State Policy, Parliamentary System, Federal System.

UNIT 2-Union Executive and State Executive: Powers of Indian Parliament Functions of Rajya Sabha, Functions of Lok Sabha, Powers and Functions of the President, Powers and Functions of the Prime Minister, Judiciary.

UNIT 3- Introduction and Basic Information about Legal System: The Court System in India and Foreign Courtiers (District Court, District Consumer Forum, Tribunals, High Courts, Supreme Court).

UNIT 4- Intellectual Property Laws and Regulation to Information: Introduction, Legal Aspects of Patents, Filing of Patent Applications, Rights from Patents, Infringement of Patents, Copyright, Information Technology Act, 2000. The Company's Act:

Reference:

1) G. Austin (2004) Working of a Democratic Constitution of India, New Delhi: Oxford University Press.
2) Basu, D.D (2005), An Introduction to the Constitution of India, New Delhi, Prentice Hall.
3) N. Chandhoke & Priyadarshini (eds) (2009) Contemporary India: Economy, Society, Politics, New Delhi: Oxford University Press.
4) N.G Jayal and P.B. Maheta, (eds) (2010) Oxford Companion to Indian Politics, New Delhi: Oxford University Press.

Indian Culture and Heritage

Course Code:	**:**	**AUC 102**	**Credits (0-0-0)**
Course Category	**:**	**Audit**	
Pre-requisite Subject	:	NIL	
Contact Hours/Week	:	1/2 Lecture : , Tutorial : , Practical:	
Number of Credits	:	0 Credit	

Course Assessment Methods: Continuous assessment through tutorials, attendance, home assignments, quizzes, practical, Tutorial class, viva voce and Minor tests and One Major Theory Examination.

Unit-I

Indian Culture: An Introduction, Characteristics of Indian culture, Significance of Geography on Indian Culture, Society in India, Religion and Philosophy in India.

Unit-II

Indian Languages and Literature, Evolution of script and languages in India, Harappan Script and Brahmi Script, History of Buddhist and Jain Literature.

Unit-III

A Brief History of Indian Arts and Architecture, Indian Art & Architecture: Gandhara School and Mathura School of Art; Hindu Temple Architecture, Buddhist Architecture, Medieval Architecture and Colonial Architecture. Indian Painting Tradition: ancient, medieval, modern Performing Arts: Divisions of Indian classical music: Hindustani and Carnatic, Dances of India: Various Dance forms: Classical and Regional, Rise of modern theatre and Indian cinema.

Unit-IV

Spread of Indian Culture Abroad, Causes Significance and Modes of Cultural Exchange - Through Traders, Teachers, Emissaries, Missionaries and Gypsies, Indian Culture in South East Asia, India, Central Asia and Western World.

Recommended Readings:

1. Barua, B. 1934-37. Barhut Vol. I-III. Calcutta: Indian Research Institute.
2. Cunningham, Alexander 1966. The Bhilsa Topes. Varanasi: Indological Book Corporation.
3. Cunningham, Alexander 1965. The Stupa of Bharhut. Varanasi: Indological Book Corporation.
4. Dallapiccola, L.S.Z. Lallemant. 1980. The Stupa : Its Religious, Historical, and Architectural Significance. Wiesbaden: Franz Steiner Verlag.
5. Dehejia, Vidya 1972. Early Buddhist Rock Temples A Chronological Study. London: Thames and Hudson

Indian Architecture

Course Code:	**:**	**AUC 103**	**Credits (0-0-0)**
Course Category	**:**	**Audit**	
Pre-requisite Subject	:	NIL	
Contact Hours/Week	:	1/2 Lecture : , Tutorial : , Practical:	
Number of Credits	:	0 Credit	

Course Assessment Methods: Continuous assessment through tutorials, attendance, home assignments, quizzes, practical, Tutorial class, viva voce and Minor tests and One Major Theory Examination.

Course outcomes

CO1- This course will help student learn about the development of Indian architecture and its contextual and traditional aspects.

CO2- The learner will gain knowledge of the development of architectural forms with reference to technology, style and character in various aspects of Hindu architecture.

CO3- The students will comprehend and relate to the theoretical basis of Budhdhist and Jain Architectures.

UNIT 1; Indus Valley Civilization: Town planning principles, cultural ethos, economy exemplified. The Aryan civilization: With its emphasis on the Vedic town plan.

UNIT 2: Buddhist Architecture Typology of lats, eddicts, stupas, viharas, and chaityas, both in rock-cut or other wise. The Buddhist philosophy and its imprint

UNIT3; Hindu Architecture, Indo Aryan: The evolution of the temple form, evolution of the shikhara in north India. The three schools of architecture - the Gujarat, the Khajuraho, and the Orrisan styles, Introduction to Dravidian Hindu Architecture.

UNIT 4: Jain Architecture : The temple cities of Palitana, Mount Abu and Girnar. Jain Theory The Jain philosophy and its imprint in built form.

REFERNCE BOOKS

1. Stella Kramrisch, The Hindu temple, Volume 1 & 2, Motilal Banarsidass Publications, 1996.
2. Percy Brown, Indian Architecture (Buddhist and Hindu period), D.B.Taraporewala Sons & co Pvt. Ltd. 1965
3. Volwahsen, Andreas, Living Architecture
4. Satish Grover, The Architecture of India- Volume 2, Vikas, 1980.
5. Henri Stierlin, Anne Stierlin, Hindu India: from Khajuraho to the temple city of Madurai, Taschen, 1998.
6. James Fergusson, History of Indian & Eastern Architecture, 2007
7. C. Batley, Design Development of Indian Architecture, John murray, London, 1934.

Indian Festivals

Course Code: : AUC 104 Credits (0-0-0)
Course Category : Audit
Pre-requisite Subject : NIL
Contact Hours/Week : ½ Lecture : , Tutorial : , Practical:
Number of Credits : 0 Credit
Course Assessment Methods: Continuous assessment through tutorials, attendance, home assignments, quizzes, practical, Tutorial class, viva voce and Minor tests and One Major Theory Examination.

Course Outcomes:

CO1-Students will learn about rich cultural aspects associated with Indian religions

CO2-The course will give deep insight in to understand the importance of festivals.

UNIT 1; Indian Festivals: Introduction to major Indian festivals Bihu, Raksha Bandhan , Onam, Pongal, Holi, Dipawali, Dushehra, Easter, Good Friday, Christmas , Eid-ul-fitr and Eid-ul-Azha , Cultural aspects of festivals .

UNIT 2 ; **Characteristics of Indian festivals** ; Seasonal in nature, seasonal festival are Agro based, worships of animals.

UNIT 3; festivals observed at same time but with different names in different parts of country.

UNIT3 : Artificial or non religious festivals- like Jaisalmer desert festivals, Mango festivals in Delhi, Elephant festivals in India. Etc.

REFERENCE BOOKS

1) Discover India; Festival of India by Sonia Mehta

2) Hindu Festival : Origin, sentiments and Rituals by Mukuncharan Das.

VAIDIC MATHEMEATICS

Course Code: : AUC 105 Credits (0-0-0)
Course Category : Audit
Pre-requisite Subject : NIL
Contact Hours/Week : 1/2 Lecture : , Tutorial : , Practical:
Number of Credits : 0 Credit
Course Assessment Methods: Continuous assessment through tutorials, attendance, home assignments, quizzes, practical, Tutorial class, viva voce and Minor tests and One Major Theory Examination.

Course outcomes:

● Vedic mathematics methods are used in coding and VLSI implementation of encryption.
● Vedic mathematics method of division, exponentiation and multiplication are used in internet security and cryptographic algorithms for making these calculations faster than before.
● Arithmetic and logic unit (ALU) is responsible for all mathematical and logical calculations in computers. Some sutras like udharvtriyakbhyam and nikhilam are used for implementing multiplication methods.
● Digital Signal Processing (DSP) includes face recognition, text speech conversion, image processing and audio -video processing and also filtering of noise. In this area VM methods are very useful to improve the performance of DSP algorithms.

UNIT-I
Introduction & history of Vedic mathematics, Arithmetic and number, Vedic Maths Formulae, Addition and Subtraction: Addition - Completing the whole , Addition from left to right , Addition of list of numbers - Shudh method , Subtraction - Base method , Subtraction - Completing the whole, Subtraction from left to right

UNIT-II

Multiplication: Ekadhikenpurven method (multiplication of two numbers of two digits), Eknunenpurven method (multiplication of two numbers of three digits), Urdhvatiragbhyam method (multiplication of two numbers of three digits), Nikhilam Navtashchramam Dashtaha (multiplication of two numbers of three digits), Combined Operations

Division and Divisibility: Division, Nikhilam Navtashchramam Dashtaha (two digits divisor), Paravartya Yojyet method (three digits divisor)

Divisibility: Ekadhikenpurven method (two digits divisor), Eknunenpurven method (two digits divisor)

UNIT-III

Least Common Multiple **(LCM)** and Highest Common Factor **(HCF)**
Power and Root Power: Square (two digit numbers), Cube (two digit numbers).
Root: Square root (four digit number), Cube root (six digit numbers)

UNIT-IV

Contribution of Indian Mathematicians (In light of Arithmetic) , Aryabhatt , Brahmagupt , Mahaveeracharya , Bharti Krishna Tirtha

Reference Books:

1. Vedic Mathematics, Motilal Banarsi Das, New Delhi.
2. Vedic Ganita: Vihangama Drishti-1, Siksha Sanskriti Uthana Nyasa, New Delhi.
3. Vedic Ganita Praneta, Siksha Sanskriti Uthana Nyasa, New Delhi.
4. Vedic Mathematics: Past, Present and Future, Siksha Sanskriti Uthana Nyasa, New Delhi.
5. Leelavati, Chokhambba Vidya Bhavan, Varanasi.
6. Bharatiya Mathematicians, Sharda Sanskrit Sansthan, Varanasi.

ASTRONOMY

Course Code:	**:**	**AUC 106**	**Credits (0-0-0)**
Course Category	**:**	**Audit**	
Pre-requisite Subject	:	NIL	
Contact Hours/Week	:	1/2 Lecture : , Tutorial : , Practical:	
Number of Credits	:	0 Credit	

Course Assessment Methods: Continuous assessment through tutorials, attendance, home assignments, quizzes, practical, Tutorial class, viva voce and Minor tests and One Major Theory Examination.

UNIT-I

Historical introduction: Old Indian and western – astronomy – Aryabhatta, Tycho Brahe, Copernicus, Galileo – Olbers paradox – solar system – satellites, planets, comets, meteorites, asteroids.
Practical astronomy – telescopes and observations & techniques – constellations, celestial coordinates, ephemeris.
Celestial mechanics – Kepler's laws – and derivations from Newton's laws.
Sun: Structure and various layers, sunspots, flares, faculae, granules, limb darkening, solar wind and climate.

UNIT-II

Stellar astronomy: H-R diagram, color-magnitude diagram – main sequence – stellar evolution – red giants, white dwarfs, neutron stars, black holes – accretion disc – Schwartzchild radius – stellar masses Saha–Boltzman equation – derivation and interpretation.

Variable stars: Cepheid, RR Lyrae and Mira type variables – Novae and Super novae. Binary and multiple star system – measurement of relative masses and velocities. Interstellar clouds – Nebulae.

UNIT-III

Transformations Generalized Coordinates, Canonical transformations, Conditions for canonical transformation and problem, Poisson brackets, invariance of PB under canonical transformation, Rotating frames of reference, inertial forces in rotating frames.

UNIT-IV

Relativity and Application Concept of Special Theory of Relativity, Lorentz Transformation, Length Contraction and time dilation, Relativistic addition of velocities, conservation of mass and momentum, Concept of General Theory of Relativity, Equivalence of mass and energy, Relativistic Doppler shift and aberration of light. Lagrangian and Hamiltonian of relativistic particles, Relativistic degenerate electron gas.

Reference Books:

1. "Textbook of Astronomy and Astrophysics with elements of Cosmology", V. B. Bhatia, Narosa publishing 2001.
2. William Marshall Smart, Robin Michael Green "On Spherical Astronomy", (Editor) Carroll, Bradley W Cambridge University Press ,1977
3. Bradley W.Carroll and Dale A. Ostlie. "Introduction to modern Astrophysics" Addison-Wesley, 1996.
4. Bradley W.Carroll and Dale A. Ostlie, "An Introduction to Modern Astrophysics" Addison Wesley Publishing Company,1996
5. 'Stellar Astronomy' by K. D Abhayankar.
6. 'Solar Physics' by K. D Abhayankar.

ARTS OF INDIA

Course Code: : AUC 107 Credits (0-0-0)
Course Category : Audit
Pre-requisite Subject : NIL
Contact Hours/Week : 1/2 Lecture : , Tutorial : , Practical:
Number of Credits : 0 Credit

Course Assessment Methods: Continuous assessment through tutorials, attendance, home assignments, quizzes, practical, Tutorial class, viva voce and Minor tests and One Major Theory Examination.

Course Outcomes:

CO1- Students will be introduced to emergence and development of art traditions upto 6th century C.E. Monuments will be studied in their cultural context.

CO2-Students will able to understand the monuments in their religious, regional and stylistic context. Students will be able to prepare plans of the monuments.

Unit 1:

Introduction to traditions of Art and Architecture in India . Introduction to Art and Architecture and prelude to historical art. ii. Art of the pre-Mauryan period. iii. Art and Architecture of Mauryan Period iv. Sources of Inspiration of Mauryan Art and Architecture: Foreign and Indigenous.

Unit 2:

Emergence and Development of Structural Stupa Architecture . Origin of Stupa Architecture. ii. Stupa Architecture - Pre-Mauryan and Mauryan periods. iii. North India, Central India, Deccan and Gandhara iv. Structural monasteries and Chaityas.

Emergence and Development of Rock-cut Architecture. Origin of Rock-cut Architecture. ii. Eastern India, Western Deccan, Eastern Deccan, Central India.

Unit 3:

Unit 4: Emergence and Development of Temple Architecture (08 hrs) i. Origin of Temple Architecture- Theoretical aspects. ii. Concept and symbolism of Temple. iii. Archaeological remains of structural temples. iv. Temple Architecture during the Gupta period. v. Temple Architecture during the Vakataka period.

Unit 4:

Sculptural Art and Paintings - Emergence and Development (10 hrs) i. Sculptural Art and Paintings -Concept and Symbolism. ii. Terracottas, Ivories and Bronzes iii. Paintings iv. Stone sculptures- Gandhara, Mathura, Sarnath and Andhra schools of Art. v. Art during the Gupta-Vakataka period.

Recommended Readings:

1. Barua, B. 1934-37. Barhut Vol. I-III. Calcutta: Indian Research Institute.
2. Cunningham, Alexander 1966. The Bhilsa Topes. Varanasi: Indological Book Corporation.
3. Cunningham, Alexander 1965. The Stupa of Bharhut. Varanasi: Indological Book Corporation.
4. Dallapiccola, L.S.Z. Lallemant. 1980. The Stupa : Its Religious, Historical, and Architectural Significance. Wiesbaden: Franz Steiner Verlag.
5. Dehejia, Vidya 1972. Early Buddhist Rock Temples A Chronological Study. London: Thames and Hudson

INTELLECTUAL PROPERTY RIGHTS

Course Code:	**:**	**AUC 108** **Credits (0-0-0)**
Course Category	**:**	**Audit**
Pre-requisite Subject	:	NIL
Contact Hours/Week	:	1/2 Lecture : , Tutorial : , Practical:
Number of Credits	:	0 Credit

Course Assessment Methods: Continuous assessment through tutorials, attendance, home assignments, quizzes, practical, Tutorial class, viva voce and Minor tests and One Major Theory Examination.

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

CO1: Create an understanding on Intellectual Properties and the importance of it.

CO2: Understand Trademarks and Trade secrets. To create awareness of unfair completion and methods of it.

CO3: Create awareness on the protection copyrights and patents. Understand the Ownership rights and transfer.

CO4: Create awareness of Cyber laws, Cyber Crime and get understanding of Privacy of Data.

CO5: To create awareness international aspects of IPR and the Emerging Trends in IPR.

Course Content

UNIT – I: Introduction to Intellectual property: Introduction, types of intellectual property—Patent, Trademarks, Copy rights, IPR and World Trade Organization, other international organizations, agencies and treaties, importance of intellectual property rights. Creating Intellectual Property. Intellectual Property Management. Emerging Issues in IPR. Research and Development in India.

UNIT – II: Fundamentals of Patent: Historical Overview of Patent Law; Concept of Patent; Patentable Inventions; Procedure for Obtaining Patent; Rights and Obligations of Patent Holder; Transfer and Infringement of Patent Rights, Geographical Indications, Case Study: Apple versus Samsung Patent Dispute.

UNIT – III: Trademarks: Purpose and function of trademarks, acquisition of trademark rights, protectable matter, selecting, and evaluating trademark, trade mark registration processes.

UNIT – IV: Copy rights: Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law. Law of patents: Foundation of patent law, patent searching process, ownership rights and transfer.

Textbooks

- Textbook of Intellectual Property Rights, N.K. Acharya. Asia Law House, ed. 2021.
- Intellectual property right, Deborah. E. Bouchoux, Cengage learning.
- Intellectual Property Rights–Pandey Neeraj, Dharni Khushdeep. PHI.
- Intellectual Property Rights: Text and Cases R. Radhakrishnan, S. Balasubramanian. Excel Books.

Reference Books

1) Intellectual property right – Unleashing the knowledge economy, Prabuddha Ganguli, Tate McGraw Hill ltd.

2) A short course in International Intellectual Property Rights – Karla C. Shippey, World Trade Press.
3) Intellectual Property Rights – Heritage, Science, & Society under international treaties – A. Subbian, - Deep & Deep Publications – New Delhi.

HUMAN RIGHTS

Course Code: : AUC 109 Credits (0-0-0)
Course Category : Audit
Pre-requisite Subject : NIL
Contact Hours/Week : 1/2 Lecture : , Tutorial : , Practical:
Number of Credits : 0 Credit
Course Assessment Methods: Continuous assessment through tutorials, attendance, home assignments, quizzes, practical, Tutorial class, viva voce and Minor tests and One Major Theory Examination.

Course Outcomes:

On completion of the course, students will be able to:

1. Simply put, human rights education is all learning that develops the knowledge, skills, and values of human rights.
2. Strengthen the respect for human rights and fundamental freedoms.
3. Enable all persons to participate effectively in a free society.
4. Learn about human rights principles, such as the universality, indivisibility, and interdependence of human rights.

UNIT-I
The Basic Concepts: Individual, Group, Civil Society, State, Equality, Justice, Human Values: Humanity, Virtues, Compassion.

UNIT-II Human Rights and Human Duties:
i) Philosophical and historical foundation of human rights and duties
ii) Theories of rights
iii) Concept and classifications of human rights and duties
iv) Human rights and duties
1. Correlation of rights and duties/responsibilities
2. Tensions between rights inter se, duties inter se, and rights and duties

UNIT-III

Society, Religion, Culture, and their Inter-Relationship: Impact of Social Structure on Human behavior, Roll of Socialization in Human Values, Science and Technology, Modernization, Globalization, and Dehumanization.

UNIT-IV

Social Structure and Social Problems: Social and Communal Conflicts and Social Harmony, Rural Poverty, Unemployment, Bonded Labour, Migrant workers and Human Rights Violations, Human Rights of mentally and physically challenged.

Books & References:

1. Shastry, T. S. N., India and Human rights: Reflections, Concept Publishing Company India (P Ltd), 2005.
2. Nirmal, C.J., Human Rights in India: Historical, Social and Political Perspectives (Law in India), Oxford India.

LOGICAL RESEARCH

Course Code:	**:**	**AUC 110**	**Credits (0-0-0)**
Course Category	**:**	**Audit**	
Pre-requisite Subject	:	NIL	
Contact Hours/Week	:	1/2 Lecture : , Tutorial : , Practical:	
Number of Credits	:	0 Credit	

Course Assessment Methods: Continuous assessment through tutorials, attendance, home assignments, quizzes, practical, Tutorial class, viva voce and Minor tests and One Major Theory Examination

Course outcomes: In this course you should develop the following competencies:

CO1: To understand about research methodology with its different aspects, about logical reasoning, and types of research.
CO2: It will also result in knowledge appraisal from data collection to data interpretation.
CO3: Mathematical reasoning will also help them to acquire several skills required for the placement.

Course Content

UNIT1- Research Methodology: meaning, characteristics, Types of research; Process of research; Research methods and Ethical issues in research.

UNIT2- Logical Reasoning: arguments, deductive and inductive research, quantitative and qualitative research, scientific research; logical approach in research - Venn diagram; Inferences; analogies.

UNIT3- Data collection, Organization of data, Data analysis and mapping, Parametric and non-parametric; Data Interpretation.

UNIT4- Mathematical Reasoning, number series, letter series, codes; relationships, classification.

References:

1. Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition
2. Business Research Methods – Alan Bryman & Emma Bell, Oxford University Press.
3.ResearchMethodology–C.R.Kothari
4. Marketing Research- G C Beri
5. Logical reasoning- R S Agarwal

PROFESSIONAL ETHICS

Course Code: : AUC 111 Credits (0-0-0)
Course Category : Audit
Pre-requisite Subject : NIL
Contact Hours/Week : 1/2 Lecture : , Tutorial : , Practical:
Number of Credits : 0 Credit

Course Assessment Methods: Continuous assessment through tutorials, attendance, home assignments, quizzes, practical, Tutorial class, viva voce and Minor tests and One Major Theory Examination.

Course Outcomes

Course Outcomes: After the completion of the course the student will be able to-
CO1: Understand the core values that shape the ethical behaviour of a professional.
CO2: Identify the multiple ethical interests at stake in a real-world situation or practice.
CO3: Explain the role and responsibility in technological development by keeping personal ethics and legal ethics.
CO4: Solve moral and ethical problems through exploration and assessment by established experiments.
CO5: Apply the knowledge of human values and social values to contemporary ethical values and global issues.

Course Content

Unit I:

Understanding Professional Ethics and Human Values: Morals, values and Ethics – Integrity-Academic integrity-Work Ethics- Service Learning- Civic Virtue Respect for others- Living peacefully- Caring and Sharing- Honestly- courage-Cooperation commitment Empathy-Self Confidence -Social Expectations.

Unit II:
Ethics for Engineers: Ethics – its importance – code of ethics – person and virtues – habits and morals – 4 main virtues – ethical theories – Kohlberg's theory – Gilligan's theory – towards a comprehensive approach to moral behaviour – truth – approach to knowledge in technology.

Unit III:
Environmental Ethics and Sustainability: Problems of environmental ethics in engineering – engineering as profession serving people – engineer's responsibility to environment – principles of sustainability – industrial, economic, environmental, agricultural, and urban sustainability – Sustainable development. - Global Ethical Issues.

Unit IV:
Social Experimentation, Responsibility and Rights: Engineers and responsible experiments – safety and risk – confidentiality – knowledge gained confidentiality – experimental nature of engineering – Intellectual Property Rights – professional rights – employee rights – occupational crime.

Textbooks

- Mike W Martin, Roland Schinzinger, " Ethics in Engineering", Tata McGraw –Hill.
- Govindarajan M, Natarajan S, Senthil Kumar V S, "Engineering Ethics" PHI India.
- R.R Gaur, R Sangal, G P Bagaria, A foundation course in Human Values and professional Ethics, Excel books, New Delhi.

Reference Books

- Aarne Vesblind, Alastair S Gunn, "Engineering Ethics and the Enviornment".
- Edmund G Seebauer, Robert L Barry, "Fundamentals of Ethics for scientists and engineers" Oxford University Press.
- B L Bajpai, 2004, Indian Ethos and Modern Management, New Royal Book Co., Lucknow. Reprinted 2008.

ENVIRONMENTAL LAWS

Course Code:	**:**	**AUC 112**	**Credits (0-0-0)**
Course Category	**:**	**Audit**	
Pre-requisite Subject	:	NIL	
Contact Hours/Week	:	1/2 Lecture : , Tutorial : , Practical:	
Number of Credits	:		

Course Assessment Methods: Continuous assessment through tutorials, attendance, home assignments, quizzes, practical, Tutorial class, viva voce and Minor tests and One Major Theory Examination.

Course Outcomes:

The course gives students the opportunity to grapple with contemporary legal debates in environment law. Therefore, the learning outcomes of this course can be encapsulated as follows:

1) The primary learning outcome is to sensitize the students towards human activities that adversely affect the environment and the need for regulation of such activities.
2) Students will develop a thorough understanding of practice and procedure followed by various environmental law enforcing agencies/bodies.
3) Students will be able to pursue environmental litigation before the National Green Tribunal and assist the Tribunal as a researcher or in any other capacity.
4) Students will be able to assist industries and projects in obtaining environmental clearance and compliances with other environmental laws.

UNIT-I

Development of Environmental Laws and Policies in India:

I. Concept of 'environment' and understanding scope of environmental law.
II. Two approaches towards environmental protection- 'Eco-centric approach' and 'Anthropocentric' approach.
III. Impact of IEL on environmental law in India.
IV. Significance of Environmental Protection in Five Year Plans.
V. Development of the 'Right to Environment' as a Fundamental Right and challenges.

UNIT-II Judicial remedies and the role of National Green Tribunal:

I. Civil Remedies i.e. Tortious remedy and Class Action
II. Criminal Law Remedies under relevant provisions of Indian Penal Code, 1860 and Criminal Procedure Code, 1973
III. Constitutional Law Remedies i.e. Writ Jurisdiction & Public Interest Litigation
IV. Statutory Remedies i.e. Remedies under Public Liability Insurance Act 1991, National Environment Tribunal Act, 1995, National Green Tribunal Act, 2010

UNIT-III

Statutory framework for Prevention of Environmental, Air and Water Pollution:

I. Water (Prevention and Control of Pollution) Act 1974 [Framework of the Act, Criminal Liability and Judicial relief under the Act, Constitutional Challenges of Restraining Orders under Section 33]
II. The Air (Prevention and Control of Pollution) Act 1981 [Framework of the Act, Criminal Liability and Judicial relief under the Act, Noise Pollution]
III. Environment (Protection) Act, 1986 [Framework of the Act, Enforcement mechanisms and Role of Pollution Control Boards, Environment Impact Assessment, Coastal zone regulations Notifications]
IV. Law on Waste Management and Handling

V. Procedural environmental rights under various environmental laws
- Right to Information
- Right to public consultation
- Right of access to justice

UNIT-IV

Statutory framework governing Forest, Wildlife and Biodiversity:

II. Statutory Framework on Forest Preservation [The Indian Forest Act, 1927; Forest (Conservation) Act, 1980; National Forest Policy, 1988; The Scheduled Tribe and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006]

III. Statutory Framework on Wildlife & Biodiversity Protection [The Wildlife (Protection) Act, 1972; Implementation and gaps and Judicial Perspective; Biological Diversity Act, 2002]

Books & References:

1) Shyam Divan & Armin Rosencranz, Environmental Law & Policy in India (2 nded, Oxford University Press, 2014)
2) P. Leelakrishnan, Environmental law in India (4th ed, LexisNexis, 2016)
3) Lavanya Rajamani and Shibani Ghosh, Indian Environmental Law: Key Concepts and Principles (Orient Blackswan, 2019)
4) Gitanjali Nain Gill, Environmental Justice in India: The National Green Tribunal (Routledge, 2017)
5) Patricia Birnie, Alan Boyle and Catherine Redgwell, International Law and the Environment (3rd ed., Oxford University Press, 2009)
6) Philippe Sands, Principles of International Environmental Law (2nd ed, Cambridge University Press, 2003)

HEALTH LAW

Course Code:	**:**	**AUC 113**	**Credits (0-0-0)**
Course Category	**:**	**Audit**	
Pre-requisite Subject	:	NIL	
Contact Hours/Week	:	½ Lecture : , Tutorial : , Practical:	
Number of Credits	:	0 Credit	

Course Assessment Methods: Continuous assessment through tutorials, attendance, home assignments, quizzes, practical, Tutorial class, viva voce and Minor tests and One Major Theory Examination

Course Outcomes: In this course you should develop the following competencies:

CO1: Knowledge and understanding of the values and policies underlying Health Law.

CO2: Knowledge and understanding of substantive law related to health care, health care insurance markets as well as related procedural law.
CO3: Written and oral communication in the legal context.

Course Content

UNIT-1 BASICS OF HEALTH LAW- Basic of Health and its provider, Origin & Evaluation, All Council Acts.

UNIT-2 NEED FOR HEALTH LAW -Fraudulence, Negligence and Abuse, Human Rights, Rights & Duties of Health Care Provider (Public & Private Activities).

UNIT-3 LEGAL ASPECTS OF HEALTH LAW- Role of Health Policy & Health Care Delivery, General Laws on Health Law (Medical Allied Agencies), Specific Laws on Health Law (NDT, PWD/etc.).

UNIT-4 MEDICAL INSURANCE –Introduction-Various types, Significance and Kind of Medical Insurance/Policies, Insurance & Assurance, General Principles of Law and Contract, Medical Insurance Regulations.

REFERENCES:
1)Jonathan Herring- Medical Law and Ethics
2)Mason and Mc Call Smith- Law and Medical Ethics
3)S. V. Jogarao- Current Issues in Criminal Justice and Medical Law

National Cadet Corps (NCC)

Course Code:	**:**	**AUC 114**	**Credits (0-0-0)**
Course Category	**:**	**Audit**	
Pre-requisite Subject	:	NIL	
Contact Hours/Week	:	½ Lecture : , Tutorial : , Practical:	
Number of Credits	:	0 Credit	

Course Outcomes: In this course you should develop the following competencies:
CO1: Imbibe the conduct of NCC cadets.
CO2: Respect the diversity of different Indian culture.
CO3: Perform his/her role in Nation Building
CO4: Do the social services on different occasions.
CO5: Practice togetherness and empathy in all walks of their life.
CO6: Do the asana and gain the physical& mental fitness

Course Content

UNIT 1
NCC General

History, Aims, Objective of NCC, NCC as Organization. Incentives of NCC, Duties of NCC

Cadet, NCC Camps: Types & Conduct.

UNIT 2

National Integration & Awareness

National Integration: Importance & Necessity, Factors Affecting National Integration, Unity in Diversity & Role of NCC in Nation Building, Threats to National Security

UNIT 3

Social Service and Community Development

Celebration of Days of National & International Importance, Social Service and Community Development Activities to be conducted.

UNIT 4

Health & Hygiene:

Yoga- Introduction, Definition, Purpose, Benefits.

Asanas-Padamsana, Siddhasana, Gyan Mudra, Surya Namaskar, Shavasana, Vajrasana, Dhanurasana, Chakrasana, Sarvaangasana, Halasana etc.

Textbooks:

1. R. Gupta, "NCC: Handbook of NCC Cadets for 'A', 'B' and 'C' Certificate Examinations" 1st Edition (English, Paperback, RPH Editorial Board)

Basics of Human Health and Preventive Medicines

Course Code:	**:**	**AUC 115**	**Credits (0-0-0)**
Course Category	**:**	**Audit**	
Pre-requisite Subject	:	NIL	
Contact Hours/Week	:	1/2 Lecture: , Tutorial : , Practical:	
Number of Credits	:	0 Credit	

Course Assessment Methods: Continuous assessment through tutorials, attendance, home assignments, quizzes, practical, Tutorial class, viva voce and Minor tests and One Major Theory Examination.

UNIT- 1

Health- Definition, dimensions, concept of wellbeing, Physical quality of life index, Spectrum of health, Determinants of health.

Concept of disease- Epidemiological triad, Natural history of disease, Risk factors, risk group, Iceberg of disease, Disease control, Disease elimination, Disease eradication, **Monitoring and surveillance-** Concept of prevention, Primary, Secondary and Tertiary, Modes of Intervention.

UNIT- 2

Communicable diseases- Type of microorganisms, Mode of transmission, Prevention of infectious diseases, Vaccination/immunization**.**

Diarrheal diseases and dehydration- Prevention and role of ORS**.**

Fever- cause and how to deal with.

Respiratory problems and cough

UNIT - 3

Non communicable diseases/ Lifestyle related disorder- Risk factors, CAD, risk and prevention, Hypertension, Diabetes mellitus, Obesity, Cancer, Accidents.

UNIT – 4
Nutrition and health- Classification of food, Balance diet.
Occupational hazards
Mental health and substance abuse
Medical Emergencies- BLS and ALS.

Reference Textbook

1) K. Park – "Park's Textbook of Preventive and Social Medicine"
2) Yash Pal Bedi & Pragya Sharma– "Handbook of Preventive and Social Medicine, Seventeenth Edition, CBS Publication".
3) Sunder Lal, Adarsh, Pankaj – "Update on Textbook of Community Medicine Preventive and Social Medicine with Recent Advances" 5th Edition, Publication 2018.
4) Dr. B. Saha- "Preventive and Social Medicine Communicable Disease Hygiene".
5) Rabindra Nath Roy, Indernil Saha- "Mahajan and Gupta Textbook of Preventive and Social Medicine" 4th Edition, Japee

CONSTITUTION OF INDIA AND ENVIRONMENTAL GOVERNANCE: ADMINISTRATION AND ADJUDICATION

Course Code	**: AUC 116**	**Credits (0-0-0)**
Course Category	**: VAC (Audit)**	
Pre-Requisite Subject	**: NIL**	
Contact Hours/ Week	**: 1 / 2 Lecture, Tutorial, Practical**	
Number of Credits	**: 0 Credit**	
Course Assessment Method	**: Continuous assessment through Tutorial classes, Home Assignments, Quizzes, Practical, Viva-Voce, Attendance, Minor Tests and One Major Theory Examination.**	

COURSE OUTCOME

At the end of the course, learners should be able to:

CO1- Understand the fundamental principles of environmental governance.

CO2- Understand Constitutional perspectives of environmental governance in India.

CO3- Procedural compliance under environmental legislations and role of Judiciary and quasi-judicial bodies in environmental governance.

CO4- Develop an understanding of bio-diversity conservation, climate change, forest protection, waste management and other issues.

COURSE CONTENTS

UNIT-I: Foundations of Environmental Law and Governance
Principles and Legal Instruments of Environmental Governance
Emerging Trends in Environmental Law

UNIT- II: Constitution of India and the articles relating Environment
Pollution Control Laws and Administrative processes
Environment Protection Act and Administrative processes
Waste Management Laws and Role of Municipalities and other agencies

UNIT- III: Basics of Forest Management in India
Judiciary and its role
Biodiversity Laws and its Application; ABS Guidelines

UNIT- IV: Wildlife Protection and management in India
Adjudicatory Mechanisms- Supreme Court, High Court, National Green Tribunal

BOOKS AND REFERENCES

- Philippe Sands, Principles of International Environmental Law, Cambridge, 2018
- Indian Environmental Law: Key Concepts and Principles, ed. Shibani Ghosh, Orient BlackSwan (2019).
- NawneetVibhaw, Environmental Law: An Introduction, LexisNexis (2016).
- Shyam Divan and Armin Rosencranz, Environmental Law and Policy in India: Cases, Material & Statutes
- Justice T S Doabia (2010) Environmental and Pollution Laws in India, Lexis Nexis Butterworths Wadhwa. Chapters 10 and 11.
- S Ghosh, S Lele, N Henle, Appellate Authorities under Pollution Control Laws in India: Powers, Problems and Potential, LEAD 2018
- Ritwick Dutta and Bhupender Yadav (2012) Supreme Court on Forest Conservation, Universal Law Publishing. Introduction (The Court's Journey through Forests) and Chapter1.
- Gitanjali Gill, Environmental Justice in India: The National Green Tribunal, Routledge (2016)
- Abhayraj Naik and Parul Kumar, India's Domestic Climate Policy is Fragmented and Lacks Clarity, available at https://www.epw.in/engage/article/indias-domestic-climate-policy-fragmented-lacks-clarity
- Suggested Documentaries- Climate Change the Facts, BBC (April, 2019)

DIRECTIVE PRINCIPLES OF STATE POLICY AND FUNDAMENTAL DUTIES: CONSTITUTIONAL IMPERATIVE

Course Code **: AUC 117** **Credits (0-0-0)**
Course Category **: VAC (Audit)**
Pre-Requisite Subject **: NIL**
Contact Hours/ Week **: 1 / 2 Lecture, Tutorial, Practical**
Number of Credits **: 0 Credit**

Course Assessment Method : Continuous assessment through Tutorial classes, Home Assignments, Quizzes, Practical, Viva-Voce, Attendance, Minor Tests and One Major Theory Examination.

COURSE OUTCOME

At the end of the course, learners should be able to:

CO1- Understand the fundamental concepts behind Directive Principles of State Policy.
CO2- Evolution and the adoption of the DPSP through the Constituent Assembly debates.
CO3- Learn how the three organs of the governance play role in shaping and achieving DPSP.
CO4- Understand the basics and relevance of Fundamental Duties.
CO5- Evaluate the relationship between Indian Knowledge System and Fundamental Duties.

COURSE LAYOUT

UNIT-I: Evolution and Concept of Directive Principles of State Policy, Incorporation of the Directive Principles of State Policy: Constituent Assembly Debates

UNIT-II: Salient Features of the Directive Principles of State Policy under the Indian Constitution, The Legislative, the Executive and the Judiciary on the Directive Principles of the State Policy

UNIT III: The Legislative, the Executive and the Judiciary on the Directive Principles of the State Policy (Cont.,), Evolution and Relevance of the Fundamental Duties

UNIT-IV: Relationship between Fundamental Duties and Indian Knowledge System, The Legislative, the Executive and the Judiciary on Fundamental Duties

BOOKS AND REFERENCES

- H.M. Seervai, Constitutional Law of India, Vol. I and 2, Universal Law Publishing (LexisNexis) 4th Edition, 2015
- Samaraditya Pal, India's Constitution: Origins and Evolution, Vol. 3, LexisNexis, 2015 Constituent Assembly Debates, Loksabha Secretariat
- Justice R C Lahoti, Fundamental Duties: A Forgotten Chapter of the Constitution, LexisNexis, 2015
- NCRWC, A Consultation Paper on Effectuation of Fundamental Duties of Citizens, 2001
- Granvile Austin, The Indian Constitution: A Cornerstone of a Nation, Oxford Clarendon Press, 1966.

INTRODUCTION TO INTELLECTUAL PROPERTY TO ENGINEERS AND TECHNOLOGISTS

Course Code : AUC 118 Credits (0-0-0)
Course Category : VAC (Audit)
Pre-Requisite Subject : NIL
Contact Hours/ Week : 1 / 2 Lecture, Tutorial, Practical
Number of Credits : 0 Credit

Course Assessment Method : Continuous assessment through Tutorial classes, Home Assignments, Quizzes, Practical, Viva-Voce, Attendance, Minor Tests and One Major Theory Examination.

COURSE OUTCOME

After the completion of the course the learners should be able to:

CO1: Create an understanding on Intellectual Properties and the importance of it.

CO2: Learn basics of Patents, Trademarks and copyrights.

CO3: Create awareness on the filing, protection copyrights and patents and understand the Ownership rights and their transfer.

CO4: Understand trade secrets and able to compare their positives and negatives traits.

CO5:, Aware of emerging trends in IPR, and learn about IP management.

COURSE LAYOUT

UNIT -I: Introduction to Intellectual Property, Types of intellectual property—Patent, Trademarks, Copy rights, IPR and World Trade Organization, Other international organizations,

UNIT -II: Basics of Patent, Patent filing procedure, Obligations of Patent Holder, Basics of Copyright- Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration Industrial Design, Emerging issue

UNIT -III: Trademark basic, Purpose and function of trademarks, acquisition of trademark rights, protectable matter, selecting, and evaluating trademark, trade mark registration processes GI basic**,** IC Layout Design

UNIT –IV: Trade secret**,** Comparative analysis, IP management

BOOKS AND REFERENCES:

- THE ECONOMIC STRUCTURE OF INTELLECTUAL PROPERTY LAW, William M. LANDES, Richard A. Posner, Harvard University Press, 2003.
- Intellectual Property and Development: Theory and Practice, Rami M. Olwan, Springer
- Narayanan, P (2006) Intellectual Property Law. 3rdedition. Eastern Law House
- Colston, C., Middleton, K. 2004 Modern Intellectual Property Law. 2nd Edition. Cavendish Publishing Ltd
- Cornish W, Llewelyn, D (2003) Intellectual Property: Patents, Copyrights, Trademarks and Allied rights. Fifth edition. Sweet and Maxwell.
- William M. Landes & Richard A. Posner, Indefinitely Renewable Copyright, 70 U. CHI. L. REV. Goldstein, Kitch and Perlman, 2006, Selected Statutes and International Agreements on Unfair Competition, Trademark, Copyright, and Patent

- Paul Goldstein, 2002, Copyright, Patent, Trademark and Related State Doctrines: Cases and Materials on Intellectual Property Law, Revised 5th edition, New York, NY: Foundation Press, 1025 pages.
- T.K.Bandyopadhyay and Saurabh Bindal, "Introduction to Intellectual Property" 1st edition Eastern Book Company, 2015

AUC119	:	**Fundamentals of Artificial Intelligence**
Course category	:	Audit Course
Pre-requisite Subject	:	Basic Programming Knowledge
Contact hours/week	:	Lecture: 2, Tutorial: 0, Practical:0
Number of Credits	:	0
Course Assessment methods	:	Continuous assessment through assignments, quizzes, tutorials, course-based project, one minor test and one major examination
Course Objectives	:	The course aims to: 1. Introduce fundamental concepts of Artificial Intelligence. 2. Develop basic Python programming skills for AI applications. 3. Build foundations in data analysis and preprocessing. 4. Provide understanding of machine learning concepts. 5. Expose students to AI use cases in various engineering domains.

Course Outcomes : After successful completion of this course, students will be able to:
CO1. Understand fundamental concepts of Artificial Intelligence and intelligent systems.
CO2. Apply Python libraries for data handling and visualization.
CO3. Perform data preprocessing and exploratory data analysis.
CO4. Understand basic machine learning concepts and evaluation metrics.
CO5. Identify and analyze AI applications in various engineering domains.
CO6. Develop simple AI-based solutions using data preprocessing, visualization, and basic machine learning models.

Topics Covered

UNIT I: Introduction to AI and Python Programming **6**

Overview of Artificial Intelligence: History, scope, types of AI, Applications of AI in modern technology, Python Basics: Data types, variables, operators, Control Structures: Conditional statements, loops, Functions and Modules, Data Structures: Lists, tuples, dictionaries, sets, File Handling Introduction to NumPy, Pandas, Matplotlib.

UNIT II: Exploratory Data Analysis **6**

Types of Data: Numerical and Categorical**,** Steps in Exploratory Data Analysis**,** Descriptive Statistics**,** Data Visualization Techniques**,** Introduction to Data-driven Decision Making.

UNIT III: Data Preprocessing and Introduction to Machine Learning 6

Data Cleaning and Deduplication, Handling Missing Data, Data Transformation: Normalization, Scaling, Binning, Introduction to Supervised and Unsupervised Learning (Conceptual Only), Model Evaluation Metrics: Accuracy, Precision, Recall, F1-score.

UNIT IV: AI Use Cases in Engineering 6

Predictive maintenance and fault detection in industrial systems using sensor data, Smart infrastructure monitoring, Process optimization, quality inspection, and automation in manufacturing environments, Intelligent decision support systems for healthcare, environmental monitoring, and cybersecurity applications.

TEXTBOOKS

1. **Aurélien Géron**, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, O'Reilly
2. **Wes McKinney**, *Python for Data Analysis*, O'Reilly
3. **Ethem Alpaydin**, *Introduction to Machine Learning*, MIT Press
4. **Jake VanderPlas**, *Python Data Science Handbook*, O'Reilly

REFERENCE BOOKS

1. **Ian Goodfellow, Yoshua Bengio, Aaron Courville**, *Deep Learning*, MIT Press
2. **Sebastian Raschka**, *Machine Learning with Python*, Packt
3. **Stuart Russell & Peter Norvig**, *Artificial Intelligence: A Modern Approach*, Pearson
4. **Andreas C. Müller & Sarah Guido**, *Introduction to Machine Learning with Python*, O'Reilly.

INDIAN KNOWLEDGE THROUGH CLASSICAL LANGUAGES

Course Code	**: IKS 101**	**Credits (0-0-0)**
Course Category	**: VAC (Audit)**	
Pre-Requisite Subject	**: NIL**	
Contact Hours/ Week	**: 1 / 2 Lecture, Tutorial, Practical**	
Number of Credits	**: 0 Credit**	
Course Assessment Method	**: Continuous assessment through Tutorial classes, Home Assignments, Quizzes, Practical, Viva-Voce, Attendance, Minor Tests and One Major Theory Examination.**	

COURSE OUTCOME:

At the end of the course learners shall be able to:

CO1- Students will be able to read, understand, and interpret the core texts of Sanskrit, Pali, Prakrit, and other Indian languages.

CO2- Students will analyze the historical and cultural significance of Indian philosophy, science, art, and social practices.

CO3- Students will develop the ability to apply the principles of Indian scriptures and folk traditions to modern contexts.

CO4- Students will critically evaluate the contributions of the Indian Knowledge Tradition in fields like medicine, architecture, and science.

CO5- Students will be equipped to promote and preserve the Indian Knowledge Tradition through innovative and creative approaches.

COURSE CONTENTS

Unit I: Sanskrit Language-Based Indian Knowledge Tradition

Objective:

To understand the fundamental principles, philosophies, and their significance in the Indian Knowledge Tradition through the Sanskrit language and its literature.

Course Content:

1. Linguistics and Literature:
   - Introduction to Sanskrit language, its grammar (morphology, phonetics), and vocabulary (words, meanings, synonyms, and prosody).
   - Key texts: Vedas (Rigveda, Yajurveda, Samaveda, Atharvaveda), Upanishads, Mahabharata, Ramayana, Puranas, and their significance.
2. Philosophy and Religion:
   - Indian philosophical systems (Yoga, Vedanta, Nyaya, Vaisheshika, Mimamsa, Sankhya).
   - Core concepts of the Bhagavad Gita and Brahmasutra.
   - Jain and Buddhist philosophies (methods, principles, and statements).
3. Science and Mathematics:
   - Mathematics: Contributions of Aryabhata, Bhaskaracharya, and Shulba Sutras.
   - Architecture: Sushruta Samhita, Charaka Samhita.
   - Ayurveda and Rasashastra (Chemistry): Contributions to medical and chemical sciences.
4. History, Culture, and Society:
   - Elements of history and culture in Sanskrit literature.
   - Kautilya's Arthashastra (practical approach).
   - Contributions of Kalidasa, Bhavabhuti, and Kabir.
   - Musicology: Gandharvacharya, Sangita Ratnakara.

Unit II: Pali Language-Based Indian Knowledge Tradition

Objective:

To understand the Buddhist perspective of the Indian Knowledge Tradition through the Pali language and its literature.

Course Content:

1. Linguistics and Literature:
   - Introduction to Pali language, its structure, grammar, and vocabulary.
   - Primary, secondary (various sutras, commentaries), and tertiary Pali literature.
2. Philosophy and Religion:
   - Buddhist philosophy: Truth and reality, the Eightfold Path, Nirvana.
   - Buddhist meditation practices and their psychological aspects.
3. Architecture and Art:
   - Buddhist architecture: Stupas (Sanchi, Amaravati), viharas, universities (Nalanda, Takshashila, etc.).
   - Buddhist art: Gandhara and Mathura styles, Buddhist iconography.

Unit III: Prakrit Language-Based Indian Knowledge Tradition

Objective:

To understand the Jain perspective of the Indian Knowledge Tradition through the Prakrit language and Jain literature.

Course Content:

1. Linguistics and Literature:
   - Introduction to Prakrit language, its dialects (Shauraseni, Magadhi, Ardhamagadhi).
   - Jain Agamas: Acharanga Sutra, Sutrakritanga, and other texts.
2. Philosophy and Religion:
   - Jain philosophy: Anekantavada (non-absolutism), Syadvada (relativity), and principles of religion.
   - Jain ethics and principles of non-violence.
3. Science and Mathematics:
   - Jain mathematics and cosmology.
   - Contributions of Jainism to astronomy and religion.
4. Culture and Art:
   - Jain architecture: Dilwara temples, Ranakpur.
   - Jain painting and sculpture.
   - Jain music and literary traditions.

Unit IV: Indian Knowledge Tradition Based on Other Indian Languages and Folk Traditions

Objective:

To understand the Indian Knowledge Tradition through Tamil, Telugu, Kannada, and other Indian languages, as well as folk traditions.

Course Content:

1. Linguistics and Literature:
   - Tamil and Telugu literature: Bhakti literature, Tirukkural, and Shaiva-Vaishnava poetry.

- Folk literature: Kabir, Gita, and oral traditions.

2. Folk Culture and Traditions:
   - Folk arts: Madhubani, Warli.
   - Folk music and dance: Bihu, Garba, Lavani.
   - Folk festivals, rituals, and oral traditions.
3. Education and Technology:
   - Tamil Siddha medicine and traditional knowledge systems.
   - Traditional water management and folk practices.
   - Folk astronomy and meteorology.
4. Social and Economic Traditions:
   - Traditional occupations and practices.
   - Folk beliefs and community life.
   - Regional festivals and their cultural significance.

Resources:

- Primary texts: Vedas, Upanishads, Puranas, Jain Agamas, Buddhist texts.
- Modern reference books: Works on Indian culture, history, and traditions.
- Digital resources: Digital libraries and online resources for Indian languages.
- Regional manuscripts and traditional knowledge systems.

INDIAN KNOWLEDGE SYSTEM: CONCEPTS AND APPLICATIONS IN SCIENCE

Course Code	**: IKS 102**	**Credits (0-0-0)**
Course Category	**: VAC (Audit)**	
Pre-Requisite Subject	**: NIL**	
Contact Hours/ Week	**: 1 / 2 Lecture, Tutorial, Practical**	
Number of Credits	**: 0 Credit**	
Course Assessment Method	**: Continuous assessment through Tutorial classes, Home Assignments, Quizzes, Practical, Viva-Voce, Attendance, Minor Tests and One Major Theory Examination.**	

COURSE OUTCOME

At the end of the course, learners should be able to:

CO1- Understand the basic concepts of Science in Indian Knowledge Systems.

CO2- Get an overview of aspects in which ancient science played impactful role.

CO3- Develop an insight for utilizing the scientific knowledge into contemporary fields.

COURSE CONTENTS

UNIT -I: Indian Knowledge System – An Introduction

The Vedic Corpus- Vedas, Upanishads, Schools of philosophy

Buddhist Corpus- Tripitakas, Jataka Tales

Jaina Corpus- Agamas

Wisdom through the Ages

UNIT- II: Number Systems and Units of Measurement

Mathematics- Overview, Vaidic and Later age mathematics
Astronomy- Overview and contributions

UNIT-III: Knowledge Framework and classifications
Linguistics- Panini & Sanskrit, Pali and Prakrit

UNIT IV: Health Wellness and Psychology
Town Planning and Architecture

BOOKS AND REFERENCES:

Mahadevan, B., Bhat Vinayak Rajat, Nagendra Pavana R.N. (2022), "Introduction to Indian Knowledge System: Concepts and Applications", PHI Learning Private Ltd. Delhi.

ADDITIONAL READINGS:

- Pride of India: A Glimpse into India's Scientific Heritage, Samskrita Bharati, New Delhi.
- Sampad and Vijay (2011). "The Wonder that is Sanskrit", Sri Aurobindo Society, Puducherry.
- Acarya, P.K. (1996). Indian Architecture, MunshiramManoharlal Publishers, New Delhi.
- Banerjea, P. (1916). Public Administration in Ancient India, Macmillan, London.
- Kapoor Kapil, Singh Avadhesh (2021). "Indian Knowledge Systems Vol – I & II", Indian .Institute of Advanced Study, Shimla, H.P
- Verma. Keshav Dev. (2012) Vedic Physics, Motilal Banarsidass Publishers.

INDIAN KNOWLEDGE SYSTEM: CONCEPTS AND APPLICATIONS IN ENGINEERING

Course Code	**: IKS 103**	**Credits (0-0-0)**
Course Category	**: VAC (Audit)**	
Pre-Requisite Subject	**: NIL**	
Contact Hours/ Week	**: 1 / 2 Lecture, Tutorial, Practical**	
Number of Credits	**: 0 Credit**	
Course Assessment Method	**: Continuous assessment through Tutorial classes, Home Assignments, Quizzes, Practical, Viva-Voce, Attendance, Minor Tests and One Major Theory Examination.**	

COURSE OUTCOME

At the end of the course, learners should be able to:
CO1- Understand the basic concepts of Engineering in Indian Knowledge Systems.
CO2- Get an overview of aspects in which ancient Engineering played an impactful role.
CO3- Develop an insight for utilizing the scientific knowledge into contemporary fields.
CO4- Understand the role of Engineering in town planning in ancient India.
CO5- Understand the interrelation of Astronomy and Architecture.

COURSE LAYOUT

UNIT-I: Indian Knowledge System – An Introduction
The Vedic Corpus

UNIT-II: Number System and Units of Measurements

Mathematics
Astronomy

UNIT-III: Engineering and Technology: Metals and Metalworking
Engineering and Technology: Other Applications

UNIT-IV: Town Planning and Architecture
Knowledge Framework and Classification
Linguistics

BOOKS AND REFERENCES:

Mahadevan, B., Bhat Vinayak Rajat, Nagendra Pavana R.N. (2022), "Introduction to Indian Knowledge System: Concepts and Applications", PHI Learning Private Ltd. Delhi.

ADDITIONAL READINGS:

- Pride of India: A Glimpse into India's Scientific Heritage, Samskrita Bharati, New Delhi.
- Sampad and Vijay (2011). "The Wonder that is Sanskrit", Sri Aurobindo Society, Puducherry.
- Bag, A.K. (1979). Mathematics in Ancient and Medieval India, Chaukhamba Orientalia, New Delhi.
- Datta, B. and Singh, A.N. (1962). History of Hindu Mathematics: Parts I and II, Asia Publishing House, Mumbai.
- Kak, S.C. (1987). "On Astronomy in Ancient India", Indian Journal of History of Science, 22(3), pp. 205–221.
- Subbarayappa, B.V. and Sarma, K.V. (1985). Indian Astronomy: A Source Book, Nehru Centre, Mumbai.
- Bag, A.K. (1997). History of Technology in India, Vol. I, Indian National Science Academy, New Delhi.
- Acarya, P.K. (1996). Indian Architecture, Munshiram Manoharlal Publishers, New Delhi.
- Banerjea, P. (1916). Public Administration in Ancient India, Macmillan, London.
- Kapoor Kapil, Singh Avadhesh (2021). "Indian Knowledge Systems Vol – I & II", Indian Institute of Advanced Study, Shimla, H.P.

INDIAN KNOWLEDGE SYSTEM

Course Code	**: IKS 104**	**Credits (0-0-0)**
Course Category	**: VAC (Audit)**	
Pre-Requisite Subject	**: NIL**	
Contact Hours/ Week	**: 1 / 2 Lecture, Tutorial, Practical**	
Number of Credits	**: 0 Credit**	
Course Assessment Method	**: Continuous assessment through Tutorial classes, Home Assignments, Quizzes, Practical, Viva-Voce, Attendance, Minor Tests and One Major Theory Examination.**	

COURSE OUTCOME

At the end of the course, learners should be able to:

CO1- Understand the history, nature and basic philosophy of Indian Knowledge System.

CO2- Develop basic understanding of ancient epistemological approaches.
CO3- Get an overview of literary and scriptural corpus of ancient India and its education system.
CO4- Develop an insight in scientific approaches relevant in contemporary times.
CO5- Understand ancient India's Governance and Public Administration.

COURSE LAYOUT

Unit 1- History of Indian Knowledge System

Genesis of Bhartiya Knowledge System
History of IKS
IKS: Nature, Philosophy and Character
India's Epistemology
Knowledge Frameworks & Classification

Unit 2- Literary Aspects of IKS

Ancient Scriptures
Ancient Education
Educating Sciences
Chandashastra (Prosody)
Bhasa Va Vyakarana (Language and Grammar)
Bharata's Natyashastra (Science of Drama, Dance and Music)
Khagol Vijnana (Astronomy)
Vastukala (Architecture)
Ayurveda
Krishi Vijnana (Agricultural) Practices

Unit 3- Scientific approaches of IKS & Torch-bearers

Dhatu Vijnana (Metallurgy)
Ganita: Mathematics in India
Yuddha Vidhya (Military Sciences)
Niyuddha Kala (Martial Arts)
Environmental Sciences

Unit 4- Governance in IKS & Way Forward

Science of Consciousness in Ancient India (Cognitive Science)
Anviksiki (Logic and Disputation)
Governance & Public Administration
IKS way forward

BOOKS AND REFERENCES:

- Introduction to Indian Knowledge System: Concepts and Applications, Archak, K.B. (2012). Kaveri Books, New Delhi.ISBN-13:978-9391818203
- Introduction To Indian Knowledge System: Concepts and Applications, Mahadevan, B.Bhat, Vinayak Rajat,Nagendra Pavana R.N.PHI, ISBN: 9789391818203

- Glimpse into Kautilya's Arthashastra Ramachandrudu P. (2010), Sanskrit Academy, Hyderabad ISBN:9788380171074
- "Introduction" in Studies in Epics and Purāṇas, (Eds.), KM Munshi and N Chandrashekara Aiyer Bhartiya Vidya Bhavan