DEPARTMENT OF CHEMICAL ENGINEERING & MATERIALS SCIENCE

B.Tech. in CHEMICAL ENGINEERING (BTC-CHE)

CURRICULUM AND SYLLABI
(2023)

GENERAL INFORMATON

ABBREVIATIONS USED IN THE CURRICULUM

Cat	-	Category
L	-	Lecture
T	-	Tutorial
P	-	Practical
Cr	-	Credits
ENGG	-	Engineering Sciences (including General, Core and Electives)
HUM	-	Humanities (including Languages and others)
SCI	-	Basic Sciences (including Mathematics)
PRJ	-	Project Work (including Seminars)

AES	-	Aerospace Engineering
AIE	-	Computer Science and Engineering - Artificial Intelligence
BIO	-	Biology
CCE	-	Computer and Communication Engineering
CHE	-	Chemical Engineering
CHY	-	Chemistry
CSE	-	Computer Science and Engineering
CIE	-	Civil Engineering
CUL	-	Cultural Education
EAC	-	Electronics and Computer Engineering
ECE	-	Electronics and Communication Engineering
EEE	-	Electrical and Electronics Engineering
ELC	-	Electrical and Computer Engineering
HUM	-	Humanities
MAT	-	Mathematics
MEE	-	Mechanical Engineering
PHY	-	Physics

Course Outcome (CO) – Statements that describe what students are expected to know, and are able to do at the end of each course. These relate to the skills, knowledge and behaviour that students acquire in their progress through the course.

Program Outcomes (POs) – Program Outcomes are statements that describe what students are expected to knowand be able to do upon graduating from the Program. These relate to the skills, knowledge, attitude and behaviourthat students acquire through the program. NBA has defined the Program Outcomes for each discipline.

PROGRAM OUTCOMES FOR ENGINEERING

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design, documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Educational Objectives (PEOs)

To produce graduates in chemical engineering, who, immediately after graduation or within five years of it:

- can apply the knowledge for engineering practice, research, and management in the chemical and allied industries such as bulk chemicals, specialty chemicals, petroleum & etrochemicals, energy, advanced materials, microelectronics, healthcare, biotechnology, consumer products, and other industries, while adhering to values in the context of ethical, health, environmental, social, safety and economic issues,

- can make worthy progress towards the acquisition of advanced degrees, are motivated to pursue additional training and certifications, and use their knowledge and skills to participate in the activities of local/national/international professional societies,
- have good written and oral communication skills, and communicate their ideas and knowledge via scholarly articles, patents, delivery of effective presentations, and/or training of co-workers and associates,
- strive for continuous self-development and life-long learning and engage in their daily work with awareness of the global or social implications.

Program Specific Outcomes (PSOs)

The undergraduate chemical engineering graduates will be able to:

PSO1: obtain, apply, and demonstrate knowledge of core concepts and principles associated with chemical engineering unit operations and unit processes, along with the associated ethics, economics, safety, and sustainability aspects required to work in manufacturing, service, and R&D sectors,

PSO2: Formulate chemical engineering problems, and then apply computational and simulation tools to solve them for effective, efficient, and sustainable design, operation, and optimization of chemical processes, while being socially and environmentally responsible, and

PSO3: plan, design and conduct scientific experiments, analyse the data, apply critical thinking to make valid inferences, and prepare technical and scholarly reports that include management and economics.

B.TECH. CHEMICAL ENGINEERING - CURRICULUM

SEMESTER I

Cat	Code	Title	L T P	Cr
HUM	23ENG101	Technical Communication	2 0 3	3
SCI	23MAT110	Calculus	2 1 0	3
ENGG	23CSE106	Computer Programming and Algorithmic Problem Solving	2 1 3	4
SCI	23PHY106	Engineering Physics B	3 0 0	3
SCI	23PHY186	Engineering Physics Laboratory B	0 0 3	1
ENGG	23MEE102	Engineering Graphics and 3D Modelling	2 0 3	3
HUM	22ADM101	Foundations of Indian Heritage	2 0 1	2
HUM	22AVP103	Mastery over Mind	1 0 2	2
		Total	**29**	**21**

SEMESTER II

Cat	Code	Title	L T P	Cr
SCI	23MAT128	Linear Algebra	2 1 0	3
ENGG	23EEE102	Basic Electrical and Electronics Engineering	3 0 0	3
SCI	23CHY110	Engineering Chemistry D	2 1 0	3
ENGG	23CHE111	Chemical Process Calculations	3 1 0	4
ENGG	23CHE113	Statics	1 0 0	1
ENGG	23CHE112	Introduction to Chemical Engineering	2 0 0	2
SCI	23CHY188	Engineering Chemistry Lab	0 0 3	1
ENGG	23EEE182	Basic Electrical and Electronics Engineering Lab	0 0 3	1
ENGG	23MEE182	Manufacturing Practice-B	0 0 3	1
HUM	22ADM111	Glimpses of Glorious India	2 0 1	2
		Total	**27**	**21**

SEMESTER III

Cat	Code	Title	L T P	Cr
SCI	23MAT220	Differential Equations	2 1 0	3
ENGG	23CHE201	Materials Technology	3 0 0	3
ENGG	23CHE202	Energy Balance and Thermodynamics	3 0 0	3
ENGG	23CHE203	Solid and Fluid Operations	3 0 0	3
ENGG	23CHE204	Fluid and Particle Mechanics	3 1 0	4
HUM		Free Elective I	2 0 0	2
ENGG	23CHE281	Industrial Chemical Technology Laboratory	0 0 3	1
HUM		Amrita Value Program I	1 0 0	1
HUM	23LAW300	Indian Constitution		P/F
HUM	23LSE201	Life Skills for Engineers I	1 0 2	P/F
		Total	**25**	**20**

SEMESTER IV

Cat	Code	Title	L T P	Cr
ENGG	23CHE211	Chemical Engineering Thermodynamics	3 0 0	3
SCI	23MAT213	Foundations of Data Science	2 1 0	3
ENGG	23CHE212	Strength of Materials	3 0 0	3
ENGG	23CHE213	Process Heat Transfer	3 1 0	4
ENGG	23CHE214	Process Instrumentation	3 0 0	3
ENGG	23CHE282	Solid and Fluid Operations Laboratory	0 0 3	1
ENGG	23CHE283	Fluid and particle Mechanics Laboratory	0 0 3	1
HUM		Amrita Value Program II	1 0 0	1
HUM	23LSE211	Life Skills for Engineers II	1 0 2	2
		Total	**26**	**21**

SEMESTER V

Cat	Code	Title	L T P	Cr
ENGG	23CHE301	Chemical Reaction Engineering	3 1 0	4
ENGG	23CHE302	Mass Transfer Operations I	3 1 0	4
POJ	23CHE303	Chemical Technology	3 0 0	3
SCI	23CHE304	Numerical Methods in Chemical Engineering	3 0 0	3
ENGG		Professional Elective 1	3 0 0	3
ENGG	23CHE381	Heat Transfer Laboratory	0 0 3	1
ENGG	23CHE382	Computational Methods in Chemical Engineering Laboratory	0 0 3	1
HUM	23LSE301	Life Skills for Engineers III	1 0 2	2
HUM	23ENV300	Environmental Science		P/F
ENGG	23LIV390***	Live-in –Lab I***		[3]
		Total	**26**	**21**

SEMESTER VI

Cat	Code	Title	L T P	Cr
ENGG	23CHE311	Mass Transfer Operations II	3 0 0	3
ENGG	23CHE312	Process Dynamics and Control	3 1 0	4
ENGG	23CHE313	Environmental Engineering and Sustainability in Process Industries	3 0 0	3
ENGG		Professional Elective 2	3 0 0	3
ENGG		Professional Elective 3	3 0 0	3
PRJ	23CHE391	Seminar	0 0 3	1
ENGG	23CHE383	Mass Transfer Laboratory	0 0 3	1
ENGG	23CHE384	Chemical Reaction Engineering and Thermodynamics Laboratory	0 0 3	1
HUM	23LSE311	Life Skills for Engineers IV	1 0 2	2
ENGG	23LIV490***	Live-in –Lab II***		[3]
		Total	**28**	**21**

SEMESTER VII

Cat	Code	Title	L T P	Cr
ENGG	23CHE401	Transport Phenomena	3 0 0	3
ENGG	23CHE402	Process Design, Integration and Economics	3 0 0	3
PROJ	23CHE403	Process Equipment Design Project	2 0 3	3
ENGG		Professional Elective 4	3 0 0	3
ENGG		Professional Elective 5	3 0 0	3
PRJ	23CHE497	Internship		P/F
ENGG	23CHE481	Chemical Process Simulation Laboratory	2 0 3	3
ENGG	23CHE482	Chemical Process Control and Instrumentation Laboratory	0 0 3	1
PRJ	23CHE498	Project Phase 1	0 0 6	2
		Total	**31**	**21**

SEMESTER VIII

Cat	Code	Title	L T P	Cr
ENGG		Professional Elective 6	3 0 0	3
ENGG		Professional Elective 7	3 0 0	3
PRJ	23CHE499	Project Phase II	0 0 30	10
		Total	**36**	**16**

Verticals
Process Data Analytics and Artificial Intelligence
Environment and Sustainability

TOTAL CREDITS	**162**
*Professional Elective - Electives categorised under Engineering, Science, Mathematics, Live-in-Labs, and NPTEL Courses. Student can opt for such electives across departments/campuses.Students with CGPA of 7.0 and above can opt for a maximum of 2 NPTEL courses with the credits not exceeding 8.	
** Free Electives - This will include courses offered by Faculty of Humanities and Social Sciences/ Faculty Arts, Commerce and Media / Faculty of Management/Amrita Darshanam -(International Centre for Spiritual Studies).	
*** Live-in-Labs - Students undertaking and registering for a Live-in-Labs project, can be exempted from registering for an Elective course in the higher semester.	

Course Evaluation Pattern

<table>
<tr><th>Course Type</th><th>Int : Ext</th><th colspan="6">Evaluation Scheme</th><th colspan="3">Total (100)</th></tr>
<tr><th>L T P</th><td rowspan="4">60 : 40</td><th>CA1</th><th>CA2</th><th>MT</th><th>CA3</th><th>CA4</th><th>ES</th><th colspan="2" rowspan="2">Int (60)</th><th rowspan="2">Ext (40)</th></tr>
<tr><td>X 0 0</td><td>Q1 / A1</td><td>Q2/A2</td><td>Exam</td><td>Q3/A3</td><td>Q4/A4</td><td>Exam/Project</td></tr>
<tr><td>X Y 0</td><td>7.5</td><td>7.5</td><td>30</td><td>7.5</td><td>7.5</td><td>40</td><td>CA (30)</td><td>MT (30)</td><td>ES (40)</td></tr>
<tr><td>X 0 Z</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="8"></th><th colspan="3">Total (100)</th></tr>
<tr><td>0 0 Z</td><td rowspan="2">60:40</td><th colspan="2">6 weeks Task or Exp.</th><th>MT</th><th colspan="2">6 weeks Task or Exp.</th><th>ES</th><th colspan="2">Int (60)</th><th>Ext (40)</th></tr>
<tr><td rowspan="2">1 0 Z</td><td colspan="2">20</td><td rowspan="2">20</td><td colspan="2">20</td><td rowspan="2">40</td><td rowspan="2">CA (40)</td><td rowspan="2">MT (20)</td><td rowspan="2">ES(40</td></tr>
<tr><td></td><td colspan="2"></td><td colspan="2"></td></tr>
</table>

Q1, Q2, Q3, Q4 refer to quizzes 1, 2, 3 and 4 respectively.

A1, A2, A3, A4 refer to assignments 1, 2, 3 and 4 respectively.

CA refers to continuous assessment

MT refers to mid-term examination

ES refers to end semester examination

* Evaluation pattern for courses which follow evaluation pattern different from the above is specified along with the syllabus for the course.

PROCESS DATA ANALYTICS AND ARTIFICIAL INTELLIGENCE VERTICAL

The vertical ***Process Data Analytics and Artificial Intelligence*** enables undergraduate students in chemical engineering to specialize in the latest trends and technologies related to advanced data analytics and the use of artificial intelligence in chemical process industries, thereby preparing them for Industry 4.0. Building on the foundations of statistics and data science, the vertical introduces students to principles of data-driven modeling, optimization, the hardware involved in Industry 4.0, machine learning, and artificial neural networks, and their applications in chemical process industries.

To successfully complete this specialization, students have to study ***six*** courses (18 credits) which are listed below:

1. **23CHE347 Industrial Statistics for Chemical Engineers -3 OR 23MAT321 - Probability and Random Processes- 3 OR 23MAT322 Probability and Statistics- 3**
2. **23CHE350 Introduction to Data-Driven Modeling in Chemical Engineering -3**
3. **23CHE357 Optimization Techniques in Chemical Engineering-3 OR 23MAT323 Optimization Techniques - 3**
4. **23CHE348 Industry 4.0 for Process Industries -3 OR 23ECE343- Wireless Sensor Networks-3 OR 23EEE321- Power Plant Instrumentation-3**
5. **23CHE352 Machine Learning in Chemical Engineering- 3 OR 23CSE325- Machine Learning-3**
6. **23CHE332 Artificial Neural Networks in Chemical Engineering-3 OR 23CSE327-Neural Networks and Deep Learning-3**

ENVIRONMENT AND SUSTAINABILITY VERTICAL

The vertical Environment and Sustainability enable undergraduate students of Chemical Engineering to acquire in-depth knowledge in wastewater design, Green Engineering, waste management, sustainable production, and consumption, and study safety aspects related to hazard management. This provides graduates the fundamental and advanced knowledge of Environmental Engineering and provides feasible solutions considering the societal and technical constraints for sustainable management and development.
To successfully complete this specialization, students have to study six courses (18 credits) which are listed below:

23CHE346	**Hazardous Waste Management**	**3**
23CHE365	**Sustainable Engineering and Life Cycle Analysis**	**3**
23CHE344	**Environmental Risk Assessment**	**3**
23CHE343	**Environmental Management**	**3**
23CHE366	**Waste to Energy Conversion**	**3**
23CHE363	**Renewable Energy Resources and Systems**	**3**
23CHE345	**Green Chemistry and Engineering**	**3**
23CHE367	**Wastewater Treatment Technologies** and Design	**3**
23CHE364	**Safety and Hazard Management in Chemical Industries**	**3**

PROFESSIONAL ELECTIVES

Cat	Code	Title	L T P	Cr
ENGG	23CHE331	Advanced Separation Processes	3 0 0	3
ENGG	23CHE332	Artificial Neural Networks in Chemical Engineering	3 0 0	3
ENGG	23CHE333	Biochemical Engineering	3 0 0	3
ENGG	23CHE334	Biomaterials	3 0 0	3
ENGG	23CHE335	Bioprocessing and Bioseparations	3 0 0	3
ENGG	23CHE336	Catalysis Science and Engineering	3 0 0	3
ENGG	23CHE337	CFD in chemical processes	3 0 0	3
ENGG	23CHE338	Chemical Engineering Software Development	3 0 0	3
ENGG	23CHE339	Chemical Process Modeling and Simulation	3 0 0	3
ENGG	23CHE340	Chemical Reactor Design and Analysis	3 0 0	3
ENGG	23CHE341	Computational materials science	3 0 0	3
ENGG	23CHE342	Electrochemical Conversion and Storage Devices	3 0 0	3
ENGG	23CHE343	Environmental Management	3 0 0	3
ENGG	23CHE344	Environmental Risk Assessment	3 0 0	3
ENGG	23CHE345	Green Chemistry and Engineering	3 0 0	3
ENGG	23CHE346	Hazardous waste management	3 0 0	3
ENGG	23CHE347	Industrial Statistics for Chemical Engineers	3 0 0	3
ENGG	23CHE348	Industry 4.0 for Process Industries	3 0 0	3
ENGG	23CHE349	Interfacial Science and Engineering	3 0 0	3
ENGG	23CHE350	Introduction to Data-Driven Modeling in Chemical Engineering	2 0 3	3
ENGG	23CHE352	Machine Learning in Chemical Engineering	3 0 0	3
ENGG	23CHE353	Material Characterization	3 0 0	3
ENGG	23CHE354	Material Processing	3 0 0	3
ENGG	23CHE355	Materials Selection and Design	3 0 0	3
ENGG	23CHE356	Nanoscience and Nanotechnology	3 0 0	3
ENGG	23CHE357	Optimization Techniques in Chemical Engineering	3 0 0	3
ENGG	23CHE358	Petroleum Refining and Petrochemical Technology	3 0 0	3
ENGG	23CHE359	Pharmaceutical Technology	3 0 0	3
ENGG	23CHE360	Polymer Materials	3 0 0	3
ENGG	23CHE361	Polymer Processing	3 0 0	3
ENGG	23CHE362	Process Intensification	3 0 0	3
ENGG	23CHE363	Renewable Energy Resources and systems	3 0 0	3
ENGG	23CHE364	Safety and Hazard Management in Chemical Industries	3 0 0	3
ENGG	23CHE365	Sustainable Engineering and Life Cycle Analysis	3 0 0	3
ENGG	23CHE366	Waste to Energy Conversion	3 0 0	3
ENGG	23CHE367	Wastewater Treatment Technologies and Design	3 0 0	3

List of courses in Amrita Value Programme I & II			
Course Code	Title	L-T-P	Credits
22ADM201	Strategic Lessons from Mahabharatha	1-0-0	1
22ADM211	Leadership from Ramayana	1-0-0	1
22AVP210	Kerala Mural Art and Painting	1-0-0	1
22AVP218	Yoga Therapy and Lessons	1-0-0	1
22AVP212	Introduction to Traditional Indian Systems of Medicine	1-0-0	1
22AVP201	Amma's Life and Message to the modern world	1-0-0	1
22AVP204	Lessons from the Upanishads	1-0-0	1
22AVP205	Message of the Bhagavad Gita	1-0-0	1
22AVP206	Life and Message of Swami Vivekananda	1-0-0	1
22AVP207	Life and Teachings of Spiritual Masters of India	1-0-0	1
22AVP208	Insights into Indian Arts and Literature	1-0-0	1
22AVP213	Traditional Fine Arts of India	1-0-0	1
22AVP214	Principles of Worship in India	1-0-0	1
22AVP215	Temple Mural Arts in Kerala	1-0-0	1
22AVP218	Insights into Indian Classical Music	1-0-0	1
22AVP219	Insights into Traditional Indian Painting	1-0-0	1
22AVP220	Insights into Indian Classical Dance	1-0-0	1
22AVP221	Indian Martial Arts and Self Defense	1-0-0	1
22AVP209	Yoga and Meditation	1-0-0	1

PROFESSIONAL ELECTIVES UNDER SCIENCE STREAM

CHEMISTRY				
Cat.	Course Code	Title	L T P	Credit
SCI	23CHY240	Computational Chemistry and Molecular Modelling	3 0 0	3
SCI	23CHY241	Electrochemical Energy Systems and Processes	3 0 0	3
SCI	23CHY242	Fuels and Combustion	3 0 0	3
SCI	23CHY243	Green Chemistry and Technology	3 0 0	3
SCI	23CHY244	Instrumental Methods of Analysis	3 0 0	3
SCI	23CHY245	Batteries and Fuel Cells	3 0 0	3
SCI	23CHY246	Corrosion Science	3 0 0	3
PHYSICS				
SCI	23PHY240	Advanced Classical Dynamics	3 0 0	3
SCI	23PHY241	Electrical Engineering Materials	3 0 0	3
SCI	23PHY242	Physics of Lasers and Applications	3 0 0	3
SCI	23PHY243	Concepts of Nanophysics and Nanotechnology	3 0 0	3
SCI	23PHY244	Physics of Semiconductor Devices	3 0 0	3
SCI	23PHY245	Astrophysics	3 0 0	3
Mathematics				
SCI	23MAT240	Statistical Inference	3 0 0	3
SCI	23MAT241	Introduction to Game Theory	3 0 0	3
SCI	23MAT242	Numerical Methods and Optimization	3 0 0	3

FREE ELECTIVES

FREE ELECTIVES OFFERED UNDER MANAGEMENT STREAM				
Cat.	Course Code	Title	L T P	Credit
HUM	23MNG331	Financial Management	3 0 0	3
HUM	23MNG332	Supply Chain Management	3 0 0	3
HUM	23MNG333	Marketing Management	3 0 0	3
HUM	23MNG334	Project Management	3 0 0	3
HUM	23MNG335	Enterprise Management	3 0 0	3
HUM	23MNG336	Operations Research	3 0 0	3
HUM	23MEE321	Industrial Engineering	3 0 0	3
HUM	23MEE322	Managerial Statistics	3 0 0	3
HUM	23MEE323	Total Quality Management	3 0 0	3
HUM	23MEE324	Lean Manufacturing	3 0 0	3
HUM	23CSE321	Software Project Management	3 0 0	3
HUM	23CSE322	Financial Engineering	3 0 0	3
HUM	23CSE323	Engineering Economic Analysis	3 0 0	3
HUM	23CSE324	Information Systems	3 0 0	3

FREE ELECTIVES OFFERED UNDER HUMANITIES / SOCIAL SCIENCE STREAMS				
Cat.	Course Code	Title	L T P	Credit
HUM	23CUL230	Achieving Excellence in Life - An Indian Perspective	2 0 0	2
HUM	23CUL231	Excellence in Daily Life	2 0 0	2
HUM	23CUL232	Exploring Science and Technology in Ancient India	2 0 0	2
HUM	23CUL233	Yoga Psychology	2 0 0	2
HUM	23ENG230	Business Communication	1 0 3	2
HUM	23ENG231	Indian Thought through English	2 0 0	2
HUM	23ENG232	Insights into Life through English Literature	2 0 0	2
HUM	23ENG233	Technical Communication	2 0 0	2
HUM	23ENG234	Indian Short Stories in English	2 0 0	2
HUM	23FRE230	Proficiency in French Language (Lower)	2 0 0	2
HUM	23FRE231	Proficiency in French Language (Higher)	2 0 0	2
HUM	23GER230	German for Beginners I	2 0 0	2
HUM	23GER231	German for Beginners II	2 0 0	2
HUM	23GER232	Proficiency in German Language (Lower)	2 0 0	2
HUM	23GER233	Proficiency in German Language (Higher)	2 0 0	2
HUM	23HIN230	Hindi I	2 0 0	2
HUM	23HIN231	Hindi II	2 0 0	2
HUM	23HUM230	Emotional Intelligence	2 0 0	2
HUM	23HUM231	Glimpses into the Indian Mind - the Growth of Modern India	2 0 0	2
HUM	23HUM232	Glimpses of Eternal India	2 0 0	2
HUM	23HUM233	Glimpses of Indian Economy and Polity	2 0 0	2
HUM	23HUM234	Health and Lifestyle	2 0 0	2

HUM	23HUM235	Indian Classics for the Twenty-first Century	2 0 0	2
HUM	23HUM236	Introduction to India Studies	2 0 0	2
HUM	23HUM237	Introduction to Sanskrit Language and Literature	2 0 0	2
HUM	23HUM238	National Service Scheme	2 0 0	2
HUM	23HUM239	Psychology for Effective Living	2 0 0	2
HUM	23HUM240	Psychology for Engineers	2 0 0	2
HUM	23HUM241	Science and Society - An Indian Perspective	2 0 0	2
HUM	23HUM242	The Message of Bhagwat Gita	2 0 0	2
HUM	23HUM243	The Message of the Upanishads	2 0 0	2
HUM	23HUM244	Understanding Science of Food and Nutrition	2 0 0	2
HUM	23HUM245	Service Learning	2 0 0	2
HUM	23JAP230	Proficiency in Japanese Language (Lower)	2 0 0	2
HUM	23JAP231	Proficiency in Japanese Language (Higher)	2 0 0	2
HUM	23KAN230	Kannada I	2 0 0	2
HUM	23KAN231	Kannada II	2 0 0	2
HUM	23MAL230	Malayalam I	2 0 0	2
HUM	23MAL231	Malayalam II	2 0 0	2
HUM	23SAN230	Sanskrit I	2 0 0	2
HUM	23SAN231	Sanskrit II	2 0 0	2
HUM	23SWK230	Corporate Social Responsibility	2 0 0	2
HUM	23SWK231	Workplace Mental Health	2 0 0	2
HUM	23TAM230	Tamil I	2 0 0	2
HUM	23TAM231	TAMIL II	2 0 0	2

SEMESTER 1

23ENG101 **TECHNICAL COMMUNICATION** **L-T-P-C: 2-0-3-3**

Pre-Requisite(s): None

Course Objectives:

- Learn the fundamentals of mechanics of writing
- Acquire the ability to draft formal correspondence and various technical documents
- Develop abilities in critical thinking and analysis
- Acquire skills of scanning for specific information, comprehension, and organization of ideas
- Enhance competency in technical presentation skills

Course Outcomes:

After the completion of the course the student will be able to

CO1:	Apply the mechanics of writing in formal correspondence
CO2:	Write technical documents with appropriate form and content
CO3:	Organize technical information or ideas in a logical and coherent manner
CO4:	Compose grammatically and stylistically accurate project reports/ term papers
CO5:	Make effective technical presentations

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]											Program Specific Outcomes [PSOs]*		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO01										3					
CO02				1						2					
CO03										3					
CO04				1						2					
CO05									2	1					

Syllabus

Unit 1

Error Analysis

Mechanics of Writing: Grammar rules -articles, tenses, auxiliary verbs (primary & modal) prepositions, subject-verb agreement, pronoun-antecedent agreement, discourse markers and sentence linkers, impersonal passive, modifiers, phrasal verbs; General Reading and Listening comprehension - rearrangement & organization of sentences

Unit 2

Different kinds of written documents: Definitions- Descriptions- Instructions-Recommendations- User manuals - Reports – Proposals; Formal Correspondence: Writing Formal Letters/Emails; Punctuation; Scientific Reading & Listening Comprehension

Unit 3

Technical paper writing: Documentation style - Document editing – Proof reading - Organizing and Formatting

Tone and style; Graphical representation; Reading and listening comprehension of technical documents; Mini Technical project / Term paper (10 -12 pages); Technical presentations

Text / Reference books:

1. Hirsh, Herbert. L *Essential Communication Strategies for Scientists, Engineers and Technology Professionals.* II Edition. New York: IEEE press, 2002
2. Anderson, Paul. V. *Technical Communication: A Reader-Centred Approach.* V Edition. Harcourt Brace College Publication, 2003
3. Strunk, William Jr. and White. EB. *The Elements of Style* New York. Alliyan & Bacon, 1999.
4. Riordan, G. Daniel and Pauley E. Steven. *Technical Report Writing* Today VIII Edition (Indian Adaptation), New Delhi: Biztantra, 2004.
5. Michael Swan. *Practical English Usage* Oxford University Press, 2000

23MAT110 CALCULUS L-T-P-C: 2-1-0-3

Course Objectives:

The following are the objectives of this course:

- Introduce the concepts of shifting and scaling of functions, their continuity, one- and two-sided limits, differentiability,
- Introduce tangents, normals, binormals, curvatures, minima and maxima of functions of single variables, and their applications,
- Introduce derivatives of functions of multiple variables and concepts of partial differentiation,
- Provide a strong foundation on the techniques of integration, evaluation of definite integrals and their engineering applications.

Course Outcomes:

After the completion of the course the student will be able to

CO1:	To understand the concepts of shifting, scaling of functions, limits, continuity, and differentiability.
CO2:	To learn definite integral, partial and total derivatives.
CO3:	To learn the scalar and vector fields, gradient, divergence and curl of vector fields and their physical interpretations
CO4:	To learn line integral, surface integral and volume integrals. To understand Greens Theorem, Divergence theorem and Stokes theorem.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	**Program Outcomes [POs]**												**Program Specific Outcomes [PSOs]***		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO01	3	1			1										
CO02	3	2			2										
CO03	3	3			1								2	1	
CO04	3	3			1								3	1	

Syllabus

Graphs: Functions and their Graphs. Shifting and Scaling of Graphs. (5 hrs)
Limit and Continuity: Limit of Functions. Continuous Functions, Discontinuities, Monotonic Functions. (5 hrs)
Graphing : Extreme Values of Functions, Concavity and Curve Sketching. (5 hrs).
Integration: Definite Integrals, The Mean Value Theorem for definite integrals, Fundamental Theorem of Calculus. (5 hrs)
Functions of severable variables: Functions, limit and continuity. Partial differentiations, total derivatives, differentiation of implicit functions and transformation of coordinates by Jacobian. Taylor's series for two variables. (10 hrs)

Vector Differentiation: Vector and Scalar Functions, Derivatives, Curves, Tangents, Arc Length, Curves in Mechanics, Velocity and Acceleration, Gradient of a Scalar Field, Directional Derivative, Divergence of a Vector Field, Curl of a Vector Field. (10 hrs)

Vector Integration: Line Integral, Line Integrals Independent of Path.

Green's Theorem in the Plane, Surfaces for Surface Integrals, Surface Integrals, Triple Integrals – Gauss Divergence Theorem, Stoke's Theorem. (10 hrs)

Textbook(s)

1. 'Calculus', G.B. Thomas Pearson Education, 2009, Eleventh Edition.

Reference(s)

1. 'Calculus', Monty J. Strauss, Gerald J. Bradley and Karl J. Smith, 3rd Edition, 2002.
2. Advanced Engineering Mathematics, E Kreyszig, John Wiley and Sons, Tenth Edition, 2018.
3. Advanced Engineering Mathematics by Dennis G. Zill and Michael R.Cullen, second edition, CBS Publishers, 2012.
4. Bruce A. Finlayson, Introduction to Chemical Engineering Computing, John Wiley & Sons, 2006

23CSE106 **COMPUTER PROGRAMMING AND ALGORITHMIC PROBLEM SOLVING** **L-T-P-C: 2-1-3-4**

Pre-Requisite(s): None

Course Objectives:

- This course provides the foundations of computational problem solving.
- The course focuses on principles and methods thereby providing transferable skills to any other domain.
- The course also provides foundation for developing computational perspectives of one's own discipline

Course Outcomes:

After the completion of the course the student will be able to

CO1:	Analyze a computational problem and develop an algorithm/flowchart to find its solution
CO2:	Develop readable* C programs with branching and looping statements, which uses Arithmetic, Logical, Relational or Bitwise operators.
CO3:	Perform code tracing by identifying computational states, bugs and correcting them.
CO4:	Develop readable multi-function/module C program by using recursion if required, to find the solution to computational problems
CO5:	Write readable C programs with pointers, arrays, structure or union to find the solution to computational problems

readable* - readability of a program means the following:
1. Logic used is easy to follow
2. Standards to be followed for indentation and formatting
3. Meaningful names are given to variables
4. Concise comments are provided wherever needed

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO01	2	3	3							2		1		2	
CO02	2	3	3	1	3					2		1		2	
CO03	2	3	3		2					2		1		2	
CO04	2	3	3	1	3					2		1		2	
CO05	2	3	3	1	3					2		1		2	

Syllabus

Unit 1

Basics of Computer Hardware and Software: Basics of Computer Architecture: processor, Memory, Input& Output devices. Application Software & System software: Compilers, interpreters, High level and low level languages. Introduction to structured approach to programming, Flow chart, Algorithms, Problem definition, logical reasoning, Algorithm – definition, practical examples, properties, representation, Constituents of algorithms, Problem Understanding and Analysis – problem definition, input-output, variables, name binding, Pseudo code (bubble sort, linear search - algorithms and pseudocode). Introduction to Flowgorithm.

Unit 2

Flowgorithm/C for problem solving – Basic structure of C program, Operators and Expressions, Operators Precedence, Control Flow Statements, Sequence, Selection and Repetition, input-output; Computation – expressions, Code tracing, Introduction to modular programming, writing functions, formal parameters, actual parameters, Pass by Value, Recursion.

Unit 3

Pointers: introduction, compatibility, arrays and pointers, Dynamic memory allocation, arrays of pointers, pointer arithmetic, Arrays – 1D numeric, searching and sorting, 2D numeric arrays, Strings: fixed length and variable length strings, strings and characters, string input, output, array of strings, string manipulation functions, sorting of strings. Structures: structure vs array comparison, complex structures, structures and functions, Union. Files and streams, file input output, command line arguments.

Textbook(s)

1. *Schaum Series, Gottfried B.S.,Tata McGraw Hill, Programming with C*
2. *E. Balagurusamy, McGraw Hill, Programming in ANSI C*
3. *Asok N Kamthane, Pearson, Programming in C*
4. *Anita Goel, Pearson, Computer Fundamentals*
5. *Riley DD, Hunt KA. Computational Thinking for the Modern Problem Solver. CRC press; 2014 Mar 27.*

Reference Books

1. *Anita Goel and Ajay Mittal, Pearson, Computer fundamentals and Programming in C*
2. *Brian W. Kernighan and Dennis M. Ritchie, Pearson, C Programming Language*
3. *Rajaraman V, PHI, Computer Basics and Programming in C*
4. *Yashavant P, Kanetkar, BPB Publications, Let us C*

TENTATIVE LIST OF LABORATORY EXERCISES

Exercises maybe solved using Flowgorithm and C

1. Familiarization of Hardware Components of a Computer
2. Familiarization of Linux/Windows environment – How to do Programming with Linux/Windows
3. Familiarization of console I/O and operators in C
    a. Display “Hello World”
    b. Read two numbers, add them and display their sum
    c. Read the radius of a circle, calculate its area and display it
    d. Evaluate the arithmetic expression ((a -b / c * d + e) * (f +g)) and display its solution. Read the values of the variables from the user through console.
4. Read 3 integer values and find the largest among them.
5. Read a Natural Number and check whether the number is prime or not
6. Read a Natural Number and check whether the number is Armstrong or not

7. Read n integers, store them in an array and find their sum and average
8. Read n integers, store them in an array and search for an element in the
9. array using an algorithm for Linear Search
10. Read n integers, store them in an array and sort the elements in the array using Bubble Sort algorithm
11. Read a string (word), store it in an array and check whether it is a palindrome word or not.
12. Read two strings (each one ending with a $ symbol), store them in arrays and concatenate them without using library functions.
13. Read a string (ending with a $ symbol), store it in an array and count the number of vowels, consonants and spaces in it.
14. Find the factorial of a given Natural Number n using recursive and non-recursive functions
15. Read a string (word), store it in an array and obtain its reverse by using a user defined function.
16. Write a menu driven program for performing matrix addition, multiplication and finding the transpose. Use functions to (i) read a matrix, (ii) find the sum of two matrices, (iii) find the product of two matrices, (i) find the transpose of a matrix and (v) display a matrix.

23PHY106 ENGINEERING PHYSICS B L-T-P-C: 3-0-0-3

Course Objective:

To expose the essentials of Newtonian mechanics, Wave optics and elemental Quantum Mechanics to the Engineering students to enable them to apply in their engineering applications.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	To apply the principles of Newtonian mechanics to engineering problems
CO2:	To understand the fundamentals of wave optics and it's applications in engineering
CO3:	To understand the essentials of Quantum mechanics and apply it to simple applications

CO-PO-PSO Mapping: [affinity$^{\#}$: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO01	3	3					-	-	-	-	-	1		-	-
CO02	3	2					-	-	-	-	-	1		-	-
CO03	3	2					-	-	-	-	-	1		-	-

Syllabus

Unit 1

Classical Mechanics: Review of Newton's third law and Free Body diagrams. Rigid body dynamics: Centre of mass. Moment of inertia. Torque, angular momentum, and angular acceleration. Work, power, and energy. Conservation of momentum. Conservation of energy. Elastic and inelastic collisions. Circular motion: Radial and tangential forces. Centripetal acceleration and centripetal force. (15 Lectures)

Unit 2

Fundamentals of Wave optics: Theory of superposition -Qualitative: Superposition of two and many Wave trains of the Same Frequency and random phase, Vector addition of amplitudes, Fresnel and Fraunhofer Diffraction - Diffraction by a single and double Slit, intensity variation in single and double slit interference, Effect of increasing the number of Slits(Grating), Intensity distribution from an Ideal grating. Resolving power of grating and grating spectra. Principles of interferometry- Theory of Michelson's Interferometer and its applications.(15 Lectures)

Unit 3

Quantum mechanics: Wave function, Probability density, expectation values - Schrodinger equation – time dependent and independent, Linearity and superposition, expectation values, operators, Eigen functions and

Eigen values. Application of 1D Schrodinger Wave equation: Free particle, Particle in a box, Finite potential well- Essentials of semiconducting materials (15 Lectures)

Reference(s):

1. Richard Wolfson, “Essential University Physics”, Vols. 1 and 2. Pearson Education, Singapore, 2011.
2. Halliday D., Resnick R. and Walker J., “Fundamentals of Physics”, Wiley Publications, 2008.
3. Francis A. Jenkins, Harvey E.White, “FUNDAMENTALS OF OPTICS” Forth edition- McGraw-Hill Publications.
4. Beiser A., "Concepts of modern physics", McGraw-Hill India, 2006.

23PHY186 ENGINEERING PHYSICS LABORATORY B L-T-P-C: 0-0-3-1

Course Objective:

- To introduce experiments for testing the understanding of physics concepts in the areas of mechanics, optics, solid state and quantum mechanics and electricity and magnetism.
- To make the student to acquire practical skills in finding properties of mater, optical properties, electrical characteristics of semiconductor materials and quantum behavior of materials.

Course Outcomes:

After the completion of this course, student will

CO1:	Be able to perform experiment to study elastic properties of materials.
CO2:	Be able to design, perform experiments on dispersion, interference and diffraction.
CO3:	Be able to design; perform experiments to measure semiconducting properties.
CO4:	Perform experiment to study atomic spectrum of H2 atom and quantum nature of light.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO01	3	1	1	1											
CO02	3	1	1	1											
CO03	3	1	1	1											
CO04	3	1	1	1											

List of Experiments:

1. Young’s modulus - non-uniform bending. [CO 1]
2. Rigidity modulus – moment of inertia of the disc and rigidity modulus of the wire using torsional oscillation. [CO 1]
3. Spectrometer- dispersive power of the material of prism. [CO 2]
4. Radius of curvature of given convex lens- Newton’s rings method. [CO 2]
5. Laser- wavelength of diode laser and mean size of Lycopodium particles. [CO 2]
6. Band gap of a semiconductor. [CO 3].
7. Solar cell - determining efficiency and fill factor. [CO 3].
8. Photoelectric effect - Planck’s constant and work function of the given metal. [CO 4]
9. Experiment to verify the quantum nature of hydrogen atom by measuring the wavelengths of spectral lines in Balmer series. [CO 4].

23MEE102	ENGINEERING GRAPHICS AND 3D MODELLING	L-T-P-C: 2-0-3-3

Pre-requisite: None

Course Objectives:

- To understand the BIS and its importance in Technical Drawings.
- To acquire proficiency in orthographic and isometric projection techniques for 2D representation of 3D objects.
- To appreciate the significance of 3D modeling in engineering design and drafting.
- To familiarize with 3D modeling software.
- Develop lateral surface development principles for creating 2D representations of 3D objects

Course Outcomes:

After successful completion of the course, Students will be able to:

Sl. No.	Course Outcomes
CO01	Demonstrate proficiency in using BIS for drafting.
CO02	Construct engineering drawings using principles of orthographic and isometric projection.
CO03	Develop models using principles of lateral surface development.
CO04	Create proficiency in developing 3D solid models using the software.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO01	3	1	3		1			3	3	3		1			
CO02	3	2	3	1	2				3	3		1			
CO03	3	3	3	1	3	1		1	3	2		1			
CO04	3	2	3	1	2			1	3	2		1			
CO05	3	1	3		1			3	3	3		1			

Syllabus

Module 1: Introduction to Engineering Graphics and 3D Modeling.

Introduction to BIS of Engineering Drawing – Line type, dimensioning, Significance of 3D modeling, Introduction to 3D Modeling Software

Module 2: Orthographic and Isometric Projections in 3D

Understanding orthographic projections of points, lines, planes, and solids in 3D, Developing 2D, projections of 3D models, Developing sectional views of 3D models of solids, Developing isometric projections from 3D models of solids, Real-world applications of orthographic projections.

Module 3: Development of Lateral Surfaces

Developing lateral surfaces of right regular prisms, cylinders, pyramids, and cones, Understanding the development of surfaces in 3D models, Real-world applications of surface development

Module 4: Advanced 3D Modeling Techniques

Advanced modeling techniques in 3D Modeling Software (Autodesk® Fusion 360®), Creating complex 3D models using multiple tools and techniques, Applications of advanced 3D modeling techniques in various industries, Exporting 3D models for prototyping and manufacturing

Note:
The course is designed to provide students with a comprehensive understanding of engineering graphics, including 2D and 3D modeling techniques. The course will also cover various real-world applications of these techniques and how they are used in different industries. Students will be expected to complete assignments and projects using 3D Modeling Software (Autodesk® Fusion 360®).
The classroom learning will be supplemented with a workbook, where the students shall have manual drawing practice for all projection-related topics

Textbooks:

- Basant Agarwal and C M Agarwal., "Engineering Drawing," 2e, McGraw Hill Education, 2015
- Autodesk Fusion 360: A Power Guide for Beginners and Intermediate Users by John Willis, Sandeep Dogra, and Cadartifex, 4e, CADArtifex

Workbook
Engineering Graphics Workbook - Developed by Department of Mechanical Engineering Faculty Members at Amrita School of Engineering, Coimbatore Campus.
Reference Books:

- Jain, Maheshwari, Gautam (2021), Engineering Graphics & Design, Khanna Book Publishing.
- Autodesk Fusion 360 For Beginners: Part Modeling, Assemblies, and Drawings – Tutorial Book
- Bhatt N.D., Panchal V.M. & Ingle P.R., (2014), Engineering Drawing, Charotar Publishing.
- John K.C., "Engineering Graphics for Degree", 1e, Prentice Hall India, 2009
- Shah, M.B. & Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson.

22ADM101 FOUNDATIONS OF INDIAN HERITAGE L-T-P-C: 2-0-1-2

Pre-Requisite(s): None

Course Objectives:

To introduce students to the depths and richness of the Indian heritage and knowledge traditions, and to enable them to obtain a synoptic view of the grandiose achievements of India in diverse fields. To equip students with a knowledge of their country and its eternal values.

Course Outcomes:

After the completion of the course the student will be able to

CO1:	Be able to enhance the understanding of true essence of India's cultural and spiritual heritage through learning analytically what it amounts to living a happy life, and about the richness of India's education system, while pondering on the serious damage caused by colonialism in India alongside learning about the means of decolonization and knowing about the early timeline of Indian subcontinent.
CO2:	Learn about the sublime value of selflessness and final freedom alongside understanding the concept of circle of life and Indian approach toward it while delving into the means of celebrating life.
CO3:	Familiarize on the topic of what true love is, by way of understanding the immense compassion of mahātmas, and Mātā Amṛtānandamayī's Amma's gospel on compassion, the role of metaphors and tropes whereafter focussing personality development through Yoga both theoretically and practically
CO4:	Appreciate the discussion on what it takes to be a strategic thinker, how India was glorified by various scholars and travellers and how strong a human being's association with nature should be alongside getting introduced to the glimpses of Indian traditions like Advaita Vedanta: the theory of oneness.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	**Program Outcomes [POs]**												**Program Specific Outcomes [PSOs]***		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO01				2				2							
CO02		1				1	1	3							
CO03						1	2	3							
CO04	3					3	3	3							

Syllabus

Unit 1

Chapters 1-4

Educational Heritage of Ancient India

Life and Happiness
Impact of Colonialism and Decolonization
A timeline of Early Indian Subcontinent

Unit- 2
Chapters 5- 8
Pinnacle of Selflessness and ultimate freedom
Indian approach towards life
Circle of Life
Ocean of love; Indian Mahatmas.

Unit 3
Chapters 9 -12
Man's association with Nature
Celebrating life 24/7.
Metaphors and Tropes
Become A Strategic Thinker (Games / Indic activity)

Unit 4
Chapters 13 -16
India: In the Views of Other Scholars and Travellers
Personality Development Through Yoga.
Hallmark of Indian Traditions: Advaita Vedanta, Theory of oneness
Conversations on Compassion with Amma

Textbook(s)

1. Foundations of Indian Heritage- In house publication

Reference Books

1. The beautiful tree by Dharampal
2. Peasants and Monks in British India by William Pinch
3. India, that is Bharat: Coloniality, Civilisation, Constitution by J Sai Deepak
4. Awaken Children Dialogues with Mata Amritanandamayi
5. Man, and Nature by Mata Amritanandamayi Devi
6. What Becomes of the Soul After Death, Divine Life Society

22AVP103	Mastery Over Mind	1-0-2-2

A. Prerequisite: NIL

B. Nature of Course: Theory

C. Course Objectives:

The course will enable the students to

- Mastery Over Mind (MaOM) is an Amrita initiative to implement schemes and organize university-wide programs to enhance health and wellbeing of all faculty, staff, and students (UN SDG -3)
- It gives an introduction to immediate and long-term benefits of MA OM meditation and equips every attendee to manage stressful emotions and anxiety, in turn facilitating inner peace and harmony.
- This course will enhance the understanding of experiential learning based on the University's mission: "Education for Life along with Education for Living" and is aimed to allow learners to realize and rediscover the infinite potential of one's true Being and the fulfilment of life's goals.

D. Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	To be able to describe what meditation is and to understand its health benefits	Understand
CO02	To understand the causes of stress and how meditation improves well-being	Remember
CO03	To understand the science of meditation	Apply
CO04	To learn and practice MAOM meditation in daily life	Understand
CO05	To understand the application of meditation to improve communication and relationships	Evaluate
CO06	To be able to understand the power of meditation in compassion-driven action	Analyse

E. CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	**Program Outcomes [POs]**												**Program Specific Outcomes [PSOs]***			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO01								1	2	2		2				
CO02			2		2				2	2		2				
CO03					2			2	2	2		2				
CO04			3		3		2	3	3	3		3				
CO05			2		2			2	2	3		3				
COO6			2					2	2	3		3				
Total			10			2		10	13	15		15				
Average $			1.3		1.5	0.3	0.3	1.67	2.16	2.5		2.5				

F. Syllabus

22AVP103	**Mastery Over Mind**	**1-0-2-2**

Unit 1: Describe Meditation and Understand its Benefits (CO1)
A: Importance of meditation. How does meditation help to overcome obstacles in life *(Pre-recorded video with Swami Shubhamritananda Puri)*
Reading 1: Why Meditate? (Swami Shubamritananda ji)

Unit 2: Causes of Stress and How Meditation Improves Well-being (CO2)
A: Learn how to prepare for meditation. Understand the aids that can help in effectively practicing meditation. Understand the role of sleep, physical activity, and a balanced diet in supporting meditation. (*Pre-recorded video with Dr. Ram Manohar)*
B: Causes of Stress. The problem of not being relaxed. Effects of stress on health. How meditation helps to relieve stress. Basics of stress management at home and the workplace. *(Pre-recorded video with Prof Udhaykumar)*
Reading 1: Mayo Clinic Staff (2022, April 29). *Meditation: A Simple, Fast Way to Reduce Stress.* Mayo Clinic. https://www.mayoclinic.org/tests-procedures/meditation/in-depth/meditation/art-20045858 (PDF provided)
Reading 2: 'Efficient Action.' Chapter 28 in *Amritam Gamaya* (2022). Mata Amritanandamayi Mission Trust.

Unit 3: The Science of Meditation (CO3)
A: A preliminary understanding of the Science of meditation. What can modern science tell us about this tradition-based method? *(Pre-recorded video with Dr. Shyam Diwakar)*
B: How meditation helps humanity according to what we know from scientific research *(Pre-recorded video with Dr. Shyam Diwakar)*
Reading 1: Does Meditation Aid Brain and Mental Health (Dr Shyam Diwakar)
Reading 2: 'Science and Spirituality.' Chapter 85 in Amritam Gamaya (2022). Mata Amritanandamayi Mission Trust.

Unit 4: Practicing MA OM Meditation in Daily Life (CO4)
Guided Meditation Sessions following scripts provided (Level One to Level Five)
Reading 1: MA OM and White Flower Meditation: A Brief Note (Swami Atmananda Puri)
Reading 2: 'Live in the Present Moment.' Chapter 71 in *Amritam Gamaya* (2022). Mata Amritanandamayi Mission Trust.

Unit 5: Improving Communication and Relationships (CO5)
How meditation and mindfulness influence interpersonal communication. The role ofmeditation in improving relationship quality in the family, at the university and in theworkplace. *(Pre-recorded video with Dr Shobhana Madhavan)*
Reading 1: Seppala E (2022, June 30th) *5 Unexpected Ways Meditation Improves Relationships a Lot.* Psychology Today. https://www.psychologytoday.com/intl/blog/feeling-it/202206/5-unexpected-ways- meditation-improves-relationships-lot
Reading 2: 'Attitude.' Chapter 53 in *Amritam Gamaya* (2022). Mata AmritanandamayiMission Trust.

Unit 6 Meditation and Compassion-driven Action (CO6)
Understand how meditation can help to motivate compassion-driven action. *(Pre-recorded video with Dr Shobhana Madhavan)*
Reading 1: Schindler, S., & Friese, M. (2022). The relation of mindfulness and prosocialbehavior: What do we (not) know?. *Current Opinion in Psychology*, *44*, 151-156.
Reading 2: 'Sympathy and Compassion.' Chapter 100 in *Amritam Gamaya* (2022). MataAmritanandamyi Mission Trust.

Course Assessment Specification Table:

		CO1	CO2	CO3	CO4	CO5	CO6	Total
1	**Reflection**					10	10	20
2	**Group Activities**	20*						20
3	**Class Participation**				40			40
4	**Written Examination**	5	5	5		5		20

*The Group Activities could be related to CO1, CO2 or CO3 depending on the preference of theinstructor

Text Books/Reference Books:

1. Meditation and Spiritual Life-Swami Yatiswarananda, Ramakrishna Math
2. The Complete Works of Swami Vivekananda Vol Vii by Advaita Ashram Mayavati Almora Himalayas
3. Dhyana Yoga-Holy Gita Swami Chinmayanda
4. Voice of God, Chandrasekharendra Saraswati, 68th Acharya of Sri Kanchi Kamakoti Peetam,
5. Hindu Dharma-Chandrasekharendra Saraswati, 68th Acharya of Sri Kanchi Kamakoti Peetam,
6. Mind: It's Mysteries and control-Swami Sivananda Saraswati
7. Amritam Gamaya (2022). Mata Amritanandamayi Mission Trust.
8. Books on Amma's teachings like Awaken children, From Amma's Heart etc.
9. The Science of Meditation: How to Change Your Brain, Mind and Body by Daniel Goleman and Richard. J. Davidson.
10. Allen, Cynthia (2020) The Potential Health Benefits of Meditation
11. Seppala E (2022, June 30th Unexpected Ways Meditation Improves Relationships a Lot.Psychology Today
12. Sharma, Hari (2022) Meditation: Process and Effects
13. Mayo Clinic Staff (2022, April 29). Meditation: A Simple, Fast Way to Reduce Stress.
14. Schindler, S., & Friese, M. (2022). The relation of mindfulness and prosocial behavior: Current Opinion in Psychology

SEMESTER 2

23MAT128 **LINEAR ALGEBRA** **L-T-P-C: 2-1-0-3**

Course Objectives:

- Understand the basic concepts of vector space, subspace, basis and dimension.
- Familiar the inner product space. Finding the orthogonal vectors using inner product.
- Understand and apply linear transform for various matrix decompositions.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	To Understand the basic concepts of vector space, subspace, basis and dimension.
CO2:	To Understand the basic concepts of inner product space, norm, angle, Orthogonality and projection and implementing the Gram-Schmidt process, to obtain least square solution
CO3:	To Understand the concept of linear transformations, the relation between matrices and linear transformations, kernel, range and apply it to change the basis and to transform the given matrix to diagonal form.
CO4:	To understand the eigen values and eigen vectors and apply to transformation problems.

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]											Program Specific Outcomes [PSOs]*		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO01	3	2													3
CO02	3	3			2										3
CO03	3	3			2								1	1	3
CO04	3	3			2								3	2	3

Syllabus

Vector Spaces: Vector spaces - Sub spaces - Linear independence - Basis – Dimension (10 hrs)

Inner Product Spaces: Inner products - Orthogonality - Orthogonal basis - Gram Schmidt Process - Change of basis - Orthogonal complements - Projection on subspace - Least Square Principle. QR- Decomposition. (10 hrs)

Linear Transformations: Linear transformation - Relation between matrices and linear transformations - Kernel and range of a linear transformation - Change of basis. Symmetric and Skew Symmetric Matrices, Adjoint and Hermitian Adjoint of a Matrix, Hermitian, Unitary and Normal Transformations, Self Adjoint and Normal Transformations. (10 hrs)

Eigen values and Eigen vectors: Eigen Values and Eigen Vectors, Diagonalization, Orthogonal Diagonalization, Quadratic Forms, Diagonalizing Quadratic Forms, Conic Sections. Similarity of linear transformations - Diagonalisation and its applications. (12 hrs)

Textbook(s)

1. Howard Anton and Chris Rorres, "Elementary Linear Algebra", Tenth Edition, John Wiley & Sons, 2010.

Reference(s)

1. Nabil Nassif, Jocelyne Erhel, Bernard Philippe, Introduction to Computational Linear Algebra, CRC press, 2015.
2. Sheldon Axler, Linear Algebra Done Right, Springer, 2014.
3. Gilbert Strang, "Linear Algebra for Learning Data", Cambridge press, 2019.
4. Kenneth Hoffmann and Ray Kunze, Linear Algebra, Second Edition, Prentice Hall, 1971.
5. Mike Cohen, Practical Linear Algebra for Data Science, Oreilly Publisher, 2022.

23EEE102	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING	L-T-P-C: 3-0-0-3

Course Objectives
- To impart basic knowledge of electrical quantities and provide working knowledge for the analysis of DC and AC circuits.
- To understand the construction and working principle of DC and AC machines.
- To facilitate understanding of basic electronics and operational amplifier circuits.

Course Outcomes
CO 1: Understand the basic electric and magnetic circuits.
CO 2: Analyse DC and AC circuits.
CO 3: Interpret the construction and working of different types of electrical machines.
CO 4: Analyse basic electronic components and circuits.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO3	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	3	3	2	-	-	-	-	-	-	-	-	-	-	-	-

Syllabus

Unit 1
Introduction to Electrical Engineering, Current and Voltage sources, Resistance, Inductance and Capacitance; Ohm’s law, Kirchhoff’s law, Energy and Power – Series parallel combination of R, L, C components, Voltage Divider and Current Divider Rules – Super position Theorem, Network Analysis – Mesh and Node methods-Faraday’s Laws of Electro-magnetic Induction, Magnetic Circuits, Self and Mutual Inductance, Generation of sinusoidal voltage, Instantaneous, Average and effective values of periodic functions, Phasor representation. Introduction to 3-phase systems, Introduction to electric grids.

Unit 2
Electrical Machines: DC Motor: Construction, principle of operation, Different types of DC motors, Voltage equation of a motor, significance of back emf, Speed, Torque, Torque-Speed characteristics, Output Power, Efficiency and applications. Single Phase Transformer: Construction, principle of operation, EMF Equation. Regulation and Efficiency of a Transformer. Induction Machine: Three Phase Induction Motor: Construction and Principle of Operation, Slip and Torque, Speed Characteristics. Stepper motor: Construction, principle and mode of operation.

Unit 3

PN Junction diodes, VI Characteristics, Rectifiers: Half wave, Full wave, Bridge. Zener Diode- characteristics, Optoelectronic devices. BJT – characteristics and configurations, Transistor as a Switch. Junction Field Effect Transistors - operation and characteristics, Thyristor – Operation and characteristics. Fundamentals of DIAC and TRIAC. 555 Timer, Integrated circuits. Operational Amplifiers – Inverting and Non-inverting amplifier – Instrumentation amplifiers.

Textbooks

1. *Edward Hughes. "Electrical and Electronic Technology", 10th Edition, Pearson Education Asia, 2019.*
2. *D. P. Kothari, I J Nagrath, "Electric Machines", 5th Edition, Tata McGraw Hill, 2017.*
3. A. *P. Malvino, "Electronic Principles", 7th Edition, Tata McGraw Hill, 2007.*

References

1. *S. K. Bhattcharya, "Basic Electrical and Electronics Engineering", Pearson, 2012.*
2. *Vincent Del Toro, "Electrical Engineering Fundamentals", Prentice Hall of India Private Limited, 2nd Edition, 2003.*
3. *David A. Bell, "Electronic Devices and Circuits", 5th Edition, Oxford University Press, 2008.*
4. *Michael Tooley B. A., "Electronic circuits: Fundamentals and Applications", 3rd Edition, Elsevier Limited, 2006.*

23CHY110 ENGINEERING CHEMISTRY D L-T-P-C: 2-1-0-3

Course Objectives:

The objective of the course is to impart knowledge on the concepts of chemistry involved in the application of engineering materials that are used in the industry/day-to day life.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Apply the principles of chemical kinetics and allied theories to predict the rate, mechanism of given chemical reaction and suitability of its scale up using chemical engineering principles
CO2:	Apply the knowledge of surface chemistry and adsorption to choose suitable materials for various chemical engineering applications, formulations and surface modifications
CO3:	Analyze various organic /inorganic materials at preliminary level using absorption spectroscopic techniques

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	**Program Outcomes [POs]**												**Program Specific Outcomes [PSOs]***		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO01	3	1	-	-	-	-	-	-	-	-	-	-	1	-	-
CO02	3	1	-	-	-	-	-	-	-	-	-	-	1	-	-
CO03	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-

Syllabus

Unit 1: Chemical kinetics

Introduction. Concept of reaction rates and order, and order of molecularity Differential and integral methods to formulate rate equations of zero, first and second order Complex reactions- parallel, consecutive and reversible reactions. Experimental methods in kinetic studies Approximation – Study state and rate determine step Theories of reaction rates - Collision theories-Modified collision theory – transition state theory.Effect of temperature on reaction rate.

Unit 2: Surface Chemistry

Colloids – classification. Solids in liquids (Sols) – optical and electrical properties, Hardy-Schultze Law. Liquids in liquids (Emulsions) -Types, preparation, Emulsifier. Liquids in solids (Gels) – Classification, preparation & properties.

Adsorption – types and nature of adsorption. Langmuir, Freundlich, multilayer B.E.T. adsorption Isotherm. Importance of adsorbent in industries. Application of adsorption - chromatography, catalysis and ion exchange adsorption and pollution abatement

Unit 3: Modern Analytical Techniques

UV-vis spectroscopy - Beer Lambert's law, electronic transition, instrumentation, and applications. Infrared spectroscopy - molecular vibrations, mode of vibration, FTIR instrumentation and applications. Flame Photometry – principle, instrumentation. Atomic Absorption Spectroscopy – principle and instrumentation, Surface area and pore size pore volume analysis by BET adsorption isotherm

Reference(s)

1. Puri, Sharma, Pathania "Principles of Physical Chemistry" 48th Edition
2. Pallab Ghosh "Colloids and Interface Science" , PHI India, 2009
3. Atkin's Physical Chemistry 12th edition, 2022
4. William Kemp "Organic Spectroscopy" 3rd edition
5. S. Lowell , Joan E. Shields , Martin A. Thomas , Matthias Thommes "Characterization of porous solids and powders: Surface area, pore size and density" Springer Publications, 2004

23CHE111 CHEMICAL PROCESS CALCULATIONS L-T-P-C: 3-1-0-4

Pre-Requisite(s): None

Course Objectives

To introduce basic principles and calculations used in chemical industries and to acquaint students to develop equations and solve problems in material balances involving unit operations and processes.

Course Outcomes

At the end of the course students would be able to:

CO1:	Calculate the composition of mixtures, conversion and yield using mixture rules, ideal gas law and reaction stoichiometry.
CO2:	Solve material balance equations for single unit and multiple unit operations using linear algebra.
CO3:	Solve material balance equations involving chemical reactions using reaction stoichiometry.
CO4:	Evaluate humidity parameters in humidification systems using humidity chart and mixture properties

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	-	-	-	-	-	-	-	2	2	-
CO2	3	3	3	3	2	-	-	-	-	-	-	-	3	2	-
CO3	3	3	3	3	2	-	-	-	-	-	-	-	3	2	-
CO4	3	3	3	3	2	-	-	-	-	-	-	-	2	3	-

Syllabus

Unit 1

Introduction to Chemical Engineering. Chemical Engineering approach-Streams, Units and Processes; Unit operations and processes: Fluid and solid operations, Heat transfer operations, Mass transfer and separation operations, Chemical reactors, Control of processes, Costing and Economics, Representing streams: Dimensions and unit conversions, Conversion factors, Dimensional consistency, Dimensionless numbers in chemical engineering, Representing compositions of mixtures and solutions: Binary and ternary mixtures, Compound stoichiometry, Representing gas phases: Ideal gas law, P-V-T calculations, Partial pressures and pure component volumes in mixtures. Representing reactions: Reaction stoichiometry, Conversion, Yield, Selectivity, Limiting and excess reactants, Dissociating gases. Representing moist gases: Humidity, Wet and dry bulb temperatures, Humidity chart

Unit 2

Material balance-Control volume, Conservation of mass and species in a unit; Steady and unsteady state processes, Batch and Continuous processes; Basis for calculation; Degrees of freedom; Steady and unsteady material balance in unit operations: Evaporation; Crystallization; Leaching; Adsorption; Drying; Liquid-Liquid Extraction; Absorption; Distillation; Recycle, Bypass and Purge

Unit 3

Combustion: Orsat analysis, Proximate and ultimate analysis of coal; Single-pass and overall conversions; Oxidation of sulphur compounds; Reactions involving phosphorous; Reactions involving nitrogen; Reactions involving chlorine; Extraction of metals from ores; Hydrogenation, hydration and oxidation; Electrochemical reactions; Recycle bypass and purge involving reactions

Textbook(s)

1. Bhatt, B.L, and Vora, S.M, Stoichiometry, 3rd Edition, Tata McGraw Hill, New Delhi,1996.
2. K.V. Narayanan & B. Lakshmikutty, Stoichiometry and Process Calculations, Prentice Hall of India, New Delhi, 2009.
3. Murphy, R.M., Introduction to Chemical Processes: Principles, Analysis, Synthesis, McGraw Hill International Edition, NewYork,2007.

Reference(s)

1. David M Himmelblau, Basic Principles and Calculations in Chemical Engineering, 6th Edition, Prentice Hall Inc., New York,2003.
2. Richard M Felder & Ronald W. Rousseau Elementary Principles of Chemical Processes, 3rd Edition, John Wiley and Sons, New York,2003.
3. Hougen, O.A, Watson K.M., and Ragatz, R.A, Chemical Process Principles Part I, CBS Publishers,1973.

23CHE112 **INTRODUCTION TO CHEMICAL ENGINEERING** **L-T-P-C: 2-0-0-2**

Pre-Requisite(s): None

Course Objectives

The students will learn different areas where Chemical Engineers have significantly contributed. After this, they will learn the fundamentals of important courses in Chemical Engineering and different physical quantities and dimensionless numbers. Further, they will develop mathematical equations for simple equipment and processes.

Course Outcomes

After the completion of this course, student will be able to

CO1:	Explain various fields to which chemical engineers have contributed and identify the roles of a modern Chemical Engineer.
CO2:	Comprehend the skeleton of Chemical Engineering curriculum, convert physical quantities from one system to another and converting them into suitable dimensionless form
CO3:	Develop process flow diagram and simple mathematical equations of a process using conservation principles and solve them using suitable mathematical techniques

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO01	3				2								3		
CO02	3												3	3	
CO03				2										3	
CO04															

Syllabus

Unit 1

Historical evolution of chemical engineering; what is chemical Engineering; the impact & role of chemical engineering; representing chemical processes using process diagrams and flow sheets (introduction to unit operations and unit processes; batch vs. continuous operation); understanding prevalent symbols; chemical process industries: evolution, broad classification, characteristics, origin, growth, present scenario, & projections; opportunities and challenges; roles of the modern chemical engineer.

Physical quantities: units & dimensions, conversion & conversion factors; important process variables, making the connection between the variables and their measurements; conventions in methods of analysis and measurement, basis, chemical equations and stoichiometry, conversion, and yield; industrially important physical and chemical properties.

Unit 2

Introduction to fluid flow (pressure-flow interaction, non-flowing fluids, pumps & turbines), heat transfer (applications of heat exchange in the industry), mass transfer (molecular vs. bulk transport), reaction engineering (important of describing reaction rate and design of reaction vessel), materials (important properties and their influence on selection of materials), and control (need for control and strategies); mathematical representation of process. Dimensional consistency and Dimensional analysis related to Chemical Engineering

Unit 3

Computer aided calculations & spreadsheets; graphing (basic plots, interpreting trends, curve fitting, log-log & semi-log representation); Relation between chemical engineering and physico–chemical sciences and other engineering disciplines; modern view of chemical engineering; economics (costs in industry, profitability considerations, analytical view of process and reporting of performance); safety-health-environment; ethics; case studies. Creating Flow sheets.
Chemical Engineering laboratory visits.

Text Book(s)

1. *K.A. Solen and J.N. Harb, Introduction to Chemical Engineering – Tools for Today and Tomorrow, 5th Edition, Wiley, 2011.*
2. *Morton M. Denn, Chemical Engineering – An Introduction, Cambridge University Press, 2012*

Reference(s)

1. *Walter L. Badger and Julius T. Banchero, Introduction to Chemical Engineering, Tata McGraw-Hill, 1955*
2. *S. Pushpavanam, Introduction to Chemical Engineering, Prentice Hall India, 2012.*

23CHE113	**STATICS**	**L-T-P-C: 1-0-0-1**

Pre-Requisite(s): None

Course Objectives

The overall objective of this course is to introduce the concept of rigid body mechanics called Statics. The understanding of rigid body mechanics is essential in engineering applications as it is used to evaluate the equilibrium of bodies subjected to forces and moments.

Course Outcomes

CO1:	Solve simple problems in resolution of forces and moment systems
CO2:	Compute rigid body equilibrium problems using free-body diagrams and accurate equilibrium equations.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	3	1										1	2
CO2	3	3	1	1									2	2	2

Syllabus

Unit 1

System of Forces: Coplanar and Concurrent Forces -Resultant – Resolution of Forces-Equilibrium of system of Forces: Free body diagrams-Equations of Equilibrium of Coplanar Systems and Spatial Systems-Moment of Forces in 2D

Textbook(s)

1. R.C. Hibbeler, Statics and Mechanics of Materials, Prentice Hall, 2013.
2. F.P. Beer, E.R. Johnston & D.Mazurek, Vector Mechanics for Engineers: Statics, McGraw-Hill Higher Education, 2012.

Evaluation Pattern

Assessment	Internal	External
*Continuous Assessment (CA)	60	
End Semester Examination		40

*Continuous Assessment: Quizzes / Assignments

23CHY188 ENGINEERING CHEMISTRY LAB L-T-P-C: 0-0-3-1

Course Objective:

- Using instrumental techniques to analyze the ions present in water.
- To understand the kinetics of chemical reactions and adsorption principles.
- To determine the rate of corrosion and its control.
- To synthesis nanoparticles and determine the surface charge of oxide particles.
- To estimate the amount of given substances using electrochemical methods.

Course Outcomes:

After the completion of this course, student will

CO1:	Analyze the ions present in the given sample water
CO2:	Analyze the adsorption isotherm and determine the rate constant of a reaction
CO3:	Apply the solid state chemistry principles for preparing nanoparticles and determining the surface charge on oxides.
CO4:	Apply the fundamental principles of electrochemistry for the analysis of given substance and understand the corrosion kinetics

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO01	3	1	-	-	1	-	1	-	1	-	-	-	-	-	-
CO02	3	1	-	-	-	-	-	-	1	-	-	-	-	-	-
CO03	3	1	-	-	-	-	-	-	1	-	-	-	-	-	-
CO04	3	1	-	-	-	-	-	-	1	-	-	-	-	-	-

Syllabus

Chemical Kinetics and surface chemistry – understanding the principle of adsorption, determining the rate constant of a reaction.

Electrochemistry – Evaluating the dissociation constant of acids, estimation of acid and ferrous ion present in water.

Corrosion and control – anodization and Tafel plot

Instrumentation techniques – Estimations of ions in water using flame photometer and UV-Visible spectrophotometer.

Solid state - Determination of point of zero charge of metal oxide.

List of Experiments:

1. Adsorption of acetic acid by charcoal
2. Adsorption of dye on charcoal
3. Determination of rate constant for acid catalyzed ester hydrolysis
4. Estimation of ferrous ion by potentiometric titration

5. Potentiometric titration of dibasic acid Vs strong base
6. Conductometric titration of mixture of acid Vs NaOH
7. Verification of B-L law by UV-spectrophotometer
8. Determination of point of zero charge of metal oxide
9. Synthesis of polyaniline conducting polymer via electrochemical polymerization
10. Synthesis of silver nanoparticle by chemical reduction method
11. Determination of sodium and potassium ions in water using Flame photometry
12. Kinetics of electrochemical reactions - Construction of Tafel linear polarization curves
13. Determination of optimum current density for the anodization of aluminium

23EEE182 **BASIC ELECTRICAL AND ELECTRONICS ENGINEERING LAB** **L-T-P-C: 0-0-3-1**

Course Objective

- To understand the basics of electrical connections and analyse the performance of electrical machines and electronic circuits.

Course Outcomes

CO1: Create basic electrical connections for domestic applications.
CO2: Measure the various electrical parameters in the circuit.
CO3: Analyse the performance of electrical machines.
CO4: Analyse basic electronic circuits.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	-	-	-	-	1	1	1	-	-	-	-	-
CO2	3	2	2	-	-	-	-	1	1	1	-	-	-	-	-
CO3	3	2	2	-	-	-	-	1	1	1	-	-	-	-	-
CO4	3	2	2	-	-	-	-	1	1	1	-	-	-	-	-

Syllabus

1. Wiring practices
2. Study of Electrical protection systems.
3. Verification of circuit theorem.
4. Experiment on DC machine.
5. Experiment on single phase Transformer.
6. Experiment on induction motor.
7. VI characteristics of PN junction and Zener diode.
8. Implementation of Half wave and Full wave rectifier using PN junction diode.
9. Transistor as a switch.
10. Experiment on Thyristor.
11. Implementation of inverting and non-inverting amplifier using Op-amp.

23MEE182 MANUFACTURING PRACTICE-B L-T-P-C: 0-0-3-1

Prerequisite: Nil

Nature of Course: Laboratory

Course Objectives:

- Imparting the knowledge of general safety procedures that should be observed on the shop floor.
- Use modelling software to design and print simple geometry for additive manufacturing processes.
- Hands-on experience in edge preparation, plate, wire and sheet joining operations.
- Explain the different tools and equipment used for basic manufacturing processes.
- Get familiar with the essential components for automation and pneumatic circuit design.
- Discuss the components and functioning of various sub-systems of automobiles, such as the power train, steering system, suspension system, and braking system.

Course Outcomes:

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

S.No.	Course Outcomes
CO01	Practice safety procedures in a shop floor environment.
CO02	Select appropriate tools and methods for basic manufacturing processes
CO03	Build simple geometries using an Additive Manufacturing process.
CO04	Perform basic metal joining using welding and soldering.
CO05	Design, simulate, and testing of simple pneumatic and electro-pneumatic circuits for automation application.
CO06	Understand the functioning of automotive systems and realize the importance of recent technological developments.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	1			1			1	1		2				
CO02	2	3				2			1	2		3				
CO03	2	2	1		3	1	1		1	2	1	3				
CO04	2	3	2						1	2	1	3				
CO05	3	2	2		3				1	2	1	3				
CO06	3	2	2		3				1	3	1	3				

Syllabus

Workshop Safety Measures and Practices - Proper training and supervision before operating unfamiliar or complex equipment.

Additive Manufacturing Laboratory –12 hours
Introduction to digital manufacturing. Introduction to Additive Manufacturing - types – additive manufacturing applications - Materials for 3D printing, CAD Modelling for Additive Manufacturing, Slicing and STL file generation- G code generation - 3D printing of simple geometries.
Mechanical Engineering Laboratory –12 hours
Study of tools and equipment used for basic manufacturing processes.
Manual arc welding practice for making Butt and Lap joints - Soldering Practice
Introduction to Machine Tools and Machining Processes
Automation Laboratory –12 hours
Design, simulation, and testing of pneumatic and electro-pneumatic circuits. Introduction to PLC–PLC programming for automation applications.
Automobile Engineering Laboratory –9 hours
Overview of automobiles – components –functioning of various sub-systems; Power train, steering system, suspension system and braking system. Introduction to electric vehicles, hybrid vehicles, alternate fuels. Introduction to E Mobility.

Reference Books:

Laboratory Manual (internal circulation)

List of Exercises:

S.No.	List of Exercises	CO mapping
1.	**General Workshop Safety Measures and Practices**	**CO01**
2.	**Additive Manufacturing Laboratory** 1. Introduction to sketching and CAD modeling for Additive Manufacturing. 2. Conversation of CAD Model to STL file, slicing, and G-code generation 3. Prototyping using 3D printing	**CO02, CO03**
3.	**Mechanical Engineering Laboratory** 1. Manual arc welding practice: butt and Lap joint. 2. Soldering practice- wire joints 3. Introduction to basic Machine tools and Machining Process – Demonstration	**CO01** **CO02, CO04**
4.	**Automation Laboratory** 1. Study of pneumatic actuators and control valves. 2. Design, simulate, and testing of pneumatic circuits. 3. Design, simulate, and testing of electro-pneumatic circuits 4. PLC programming for automation applications.	**CO05**
5.	**Automobile Engineering Laboratory** 1. Demonstrate the working of various subsystems of automobiles- Power train, steering system, suspension system, and braking system. 2. Demonstrate the working of electric and hybrid vehicles.	**CO06**

22ADM111 GLIMPSES OF GLORIOUS INDIA L-T-P-C: 2-0-1-2

Pre-Requisite(s): None

Course Objectives:

The course aims at introducing Bhārath in nutshell to the student, which includes the sources of Indian thoughts, eminent personalities who shaped various disciplines, India's significant contribution to the man kind, the current stature of Indian in the geopolitics and Indian approach to science and ecology.

Course Outcomes:

After the completion of the course the student

CO1:	Will be able to recognise the call of Upanishads and outstanding personalities for confronting the wicked in the real world while admiring the valour, pursuit and divinity in both classical and historical female characters of India.
CO2:	Will get introduced to Acharya Chanakya, his works, and his views on polity and nation to find synchrony between public and personal life, alongside understanding India's cultural nuances and uniqueness concerning the comprehension of God across major global communities.
CO3:	Will be able to appreciate Bhagavad Gita as the source of the Indian worldview through the various Yogic lessons enshrined in it, making it one of India's numerous soft powers, and also understand the faith-oriented mechanism of preserving nature.
CO4:	Will be informed about the enormous contribution of Indian civilisation over two and a half millennia to humanity and develop awareness about India's approach toward science, devoid of dogmas and rooted in humanism.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO01			1	2				2							
CO02	2	1				1		3	1						
CO03	2		1	2	1	1		3							
CO04	2			3				3	2						

Syllabus

Unit-1

1. Chapter 1 – Face the Brutes
2. Chapter 2 – Role of Women in India
3. Chapter 3 – Acharya Chanakya
4. Chapter 4 – God and Iswara

Unit-2

5. Chapter 5 – Bhagavad Gita: From Soldier to Samsarin to Sadhaka
6. Chapter 6 – Lessons of Yoga from Bhagavad Gita

7. Chapter 7 – Indian Soft powers
8. Chapter 8 – Preserving Nature through Faith

Unit-3

9. Chapter 9 - Ancient Indian Cultures (Class Activity)
10. Chapter 10 - Practical Vedanta
11. Chapter 11 - To the World from India
12. Chapter 12 - Indian Approach to Science

Textbook(s)

1. *Glimpses of Glorious India- In-house publication*

Reference(s)

1. Fear Not: Be Strong (Swami Tathagatananda)
2. Essays on Gita (Sri Aurobindo)- Aurobindo Ashram
3. Indian Contribution to Science (Vijana Bharati Publication)
4. The Culture And Civilisation Of Ancient India In Historical Outline (D. D. Kosambi)
5. The Kautilya Arthashastra by Chankaya – Translation with critical and explanatory note by R P Kangle – Motilal Banarasidass Publishers- 1972
6. Chanakya Neeti – Strategies for success – Radhakrishnan pillai – Jaico Publishing house -2020.
7. Universal Message of the Bhagavad Gita: An exposition of the Gita in the Light of Modern Thought and Modern Needs. - Swami Ranganathananda, Advaita Ashrama Belur Math, 2000.
8. A Concise History Of Science In India – D M Bose, S N Sen, B V Subbarayappa,The Indian National Science Academy 1971.
9. Indian Culture and India's Future – Michel Danino - D.K. Printworld (P) Ltd -2011.

SEMESTER 3

23MAT220 DIFFERENTIAL EQUATIONS L-T-P-C: 2-1-0-3

Course Objectives

- To model spatiotemporal variations in engineering systems and processes using differential equations
- To analyze and solve ordinary differential equations (ODE)
- To analyze stability of systems of first order ordinary differential equations
- To define Laplace transforms and utilize them to solve linear first and second order ODEs
- To understand partial differential equations and its applications in engineering

Course Outcomes

CO1:	Define first-order ordinary differential equations and demonstrate ability to use techniques to solve them and apply these solutions in engineering contexts.
CO2:	Reduce higher-order ordinary differential equations to a system of first-order differential equations, solve them using the method of eigenvector expansions and apply the solutions to engineering problems.
CO3:	Define second-order ordinary differential equations and demonstrate ability to use techniques to solve them and apply these solutions in engineering contexts.
CO4:	Define Laplace transforms and their inverses, apply their properties to solve linear ordinary differential equations.
CO5:	Understand the types of partial differential equations arising from two-dimensional modeling. Use separation of variables to solve linear partial differential equations.

CO-PO-PSO Mapping: [affinity$^{\#}$: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2			2								2		
CO2	3	2			2										
CO3	3	3			2										
CO4	3	3			1										
CO5	3		3		1										

Syllabus:

Unit 1

One-Dimensional Modeling: Origin of Ordinary Differential Equations (1st and 2nd Order); First Order OD: Direct Integration, Integrating Factor – Linear and Nonlinear Equations; Systems of First Order ODEs. Stability. (12 hrs)

Unit 2

Second Order ODE: Homogeneous and Non-homogeneous – Linear equations with constant coefficients; Laplace Transforms: Definition, Properties and Inverse Laplace Transforms; Solution of Linear First and Second Order ODEs using Laplace Transforms. Fixed points, stability of fixed points. (15 hrs)

Unit 3

Two-Dimensional Modeling: Partial Differential Equations, classifications of PDE, Separation of Variables: Fourier Series, arbitrary period, even and odd expressions, half range expressions. Fourier serious solutions of one dimensional Heat and wave Equations. (15 hrs)

Textbook(s):

1. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, Wiley-India Pvt. Ltd., 2011

Reference(s):

1. Michael Greenberg, Advanced Engineering Mathematics, 2nd Edition, Pearson, 2011
2. Bruce A. Finlayson, Introduction to Chemical Engineering Computing, John Wiley & Sons, 2006.
3. Engineering Mathematics, Srimanta Pal and Subodh C Bhunia, Oxford university press, 2015.
4. Advanced Engineering Mathematics, Wylie and Barrett, 6th Edition, McGraw Hall India, 2015.

23CHE201 MATERIALS TECHNOLOGY L-T-P-C: 3-0-0-3

Pre-Requisite(s): None

Course Objectives:

This course provides students an understanding of basic structure and crystal arrangement of materials, mechanical behaviour of materials, the phase diagrams, alloying elements used in steel, the effect of heat treatment on the properties of metals, and the synthesis of nanomaterials

Course Outcomes:

CO1:	Represent the directions, planes and determine linear and planar atomic density in cubic crystal structures
CO2:	Explicate the different types of deformation and mechanical behavior of materials
CO3:	Elucidate the various mechanical testing methods to evaluate the properties of materials
CO4:	Interpret the phase diagrams of selected alloy systems and explain different heat treatment techniques
CO5:	Outline the methods employed for nanomaterials synthesis

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2											2		
CO2	2	2	3										2		
CO3	3	3	3	3									3	3	
CO4	2	3	3	2									3	2	2
CO5	2	2	2	2										3	3

Syllabus

Unit 1

Basics of Materials Structure: crystal systems – space lattice – miller indices of atomic planes and directions – small problems in crystallography – crystal defects point, line and surface defects. Mechanical Behaviour of Materials: stress- strain curve – elastic deformation- characteristics of elastic deformation-atomic mechanism of elastic deformation-inelastic deformation- strain time curves – viscous deformation-plastic deformation- -slip and Twinning-Schmidt’s law- critical resolved shear stress – Strengthening mechanisms; work hardening-grain boundary hardening, dispersion hardening.

Unit 2

Mechanical Testing and Fracture of Materials : Tensile test- stress – strain curves for ductile and brittle materials – proof stress – Compression test – Hardness test – Impact test – Fatigue test –S-N curve – Creep; primary, secondary and tertiary creep- Fracture: Ideal fracture stress – brittle fracture – Griffith’s theory cup and cone type fracture Phase Diagrams: solid solution – intermetallic compound, cooling, curves, non-equilibrium cooling-phase rule-Equilibrium diagrams- isomorphous- eutectic, peritectic and eutectoid reactions with examples-Iron-Iron carbide phase diagram.

Unit 3

Engineering materials: steels and cast irons- properties and applications- Heat treatment of steels: Annealing – Normalizing- Hardening-Tempering- Hardenability and its testing – TTT diagram Nanomaterials - Synthesis - Chemical routes methods -Thin films methods- chemical vapor deposition- physical vapor deposition -ball milling- mechanical attrition. Special nanomaterials: carbon nanotubes, fullerenes, nanowires

Textbook(s)

1. R. Balasubramaniam, Callister's Materials Science and Engineering, Wiley, 2013.
2. W F Smith, J Hashemi, R Prakash, Materials Science and Engineering, McGraw Hill 2008.

Reference Book(s)

1. L H Van Vlack, Elements of Materials Science and Engineering , Pearson India 2008
2. D.R .Askeland, P. P Fulay, W. J .Wright,The Science and Engineering of Materials, CL Engineering 2012.
3. F. J. Owens and C.P. Poole Jr, The Physics and Chemistry of Nanosolids, Wiley-Interscience, 2008

23CHE202	ENERGY BALANCE AND THERMODYNAMICS	L-T-P-C: 3-0-0-3

Pre-Requisite(s): Chemical Process Calculations

Course Objectives

The objective of the course is to understand thermodynamic laws and perform energy balances on control volumes, closed systems, various unit operations, processes and gas cycles.

Course Outcome

After the completion of this course, student will be able to

CO1:	Estimate the property change during thermodynamic processes (isothermal, isobaric, isochoric, adiabatic and polytropic) for a single phase, closed and open systems using thermodynamic laws and equations of state
CO2:	Evaluate thermodynamic properties of pure substances under phase change processes using property tables and equations of states
CO3:	Solve energy balance equations for steady flow energy changing devices and unit operations using conservation of energy principles.
CO4:	Estimate thermodynamic efficiencies of different thermodynamic cycles using energy balance equations

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO1	PSO2	PSO3
CO1	3	3	3	2	-	-	-	-	-	-	-	-	3	3	-
CO2	2	3	2	3	-	-	-	-	-	-	-	-	3	2	-
CO3	3	3	2	3	-	-	-	-	-	-	-	-	3	2	-
CO4	3	3	2	3	-	-	-	-	-	-	-	-	3	2	-

Syllabus

Unit 1

Systems, Properties, Processes, Cycles; State of a system and state postulate; State and path functions; Temperature and zeroth law of thermodynamics; Pressure and pressure measurement; Energy and its forms: Potential and Kinetic energy, Internal energy; Energy sources; Energy transfer – Heat, Work, Electricity; Mechanisms of heat transfer; Work: Moving boundary work, Flow work, Shaft, spring, elasticity, surface tension, and electrical work; Energy balance – First law for open and closed systems, steady and unsteady state processes.

Phases and phase diagrams of a pure substance, Saturation, Superheating, T-v, P-v, P-T diagrams and the P-v-T surface; Enthalpy; Property tables; Ideal and non-ideal gases: Evaluation of thermodynamic parameters using equations of state: van der Waals, Soave-Redlich-Kwong, Peng-Robinson equations of state; Virial equation and its physical meaning; Compressibility factor.

Unit 2

Estimation of heat capacities: Solids, Liquids, Gases, Mixtures, Temperature dependence; Enthalpy changes: Mixing, Fusion, Vaporization – Clapeyron equation, Clausius-Clapeyron equation, Watson equation, Trouton's rule, Kistiakowsky equation; Energy analysis of gas cycles; Energy analysis using property tables.
Mechanical energy balance – Bernoulli equation; Energy transfer by mechanical work: Nozzles and diffusers, Turbines, compressors and pumps, Throttling valves, Pipe and duct flow; Energy transfer by heat: Heat exchangers, Boilers and Furnaces; Energy balance in unit operations: Mixers and splitters; Drying; Evaporation; Crystallization; Leaching; Adsorption; Liquid-Liquid Extraction; Absorption; Distillation; membrane separatCheion processes, Recycle, Bypass, Purge.

Unit 3

Entropy and thermodynamic temperature; Combined first and second law for closed systems and cycles: Carnot cycle; Refrigerators, Heat pumps: energy and exergy analysis Thermodynamic efficiency and coefficient of performance; Second law for open systems – Entropy balance; Statistical meaning of entropy, Standard heat of reactions – Combustion and Formation; Hess's law; Effect of temperature and pressure; Adiabatic reaction temperature

Text Book(s)

1. Cengel Y. A., and Boles, M. A., Thermodynamics: An Engineering Approach, 7th Special Indian Edition, McGraw-Hill India, New Delhi, 2011
2. Rao, Y. V. C., Chemical Engineering Thermodynamics, Universities Press, 1997
3. J.M Smith, H C Van Ness, M M Abbott, Introduction to Chemical Engineering Thermodynamics, 2010.

Reference(s)

1. Narayanan, K. V., and Lakshmikutty B., Stoichiometry and Process Calculations, Prentice Hall India, New Delhi, 2009
2. Murphy, R. M., Introduction to Chemical Processes: Principles, Analysis, Synthesis, McGraw Hill International Edition, New York, 2007
3. O'Connell, J. P., and Haile, J. M., Thermodynamics: Fundamentals for Applications, Cambridge University Press, Cambridge, 2005

23CHE203 SOLID AND FLUID OPERATIONS L-T-P-C: 3-0-0-3

Pre-Requisite(s): None

Course Objectives

The objective of the course is to understand various aspects related to particle characterization, handling, and solids transportation. The course also aims to make students proficient in understanding various size-reduction equipment and develop expertise in handling agitators, dewatering equipment, and other unit operations involving solid separation from fluids.

Course Outcomes

After the completion of this course, student will be able to

CO 1:	Develop professional expertise in particle characterization and solids handling and transportation
CO 2:	Recognise the selection of size-reduction equipment with fundamental knowledge of crushing laws
CO 3:	Express proficiency in handling equipment related to solids separation from fluids in industrial applications
CO4:	Infer understanding of agitators used in industrial mixing with emphasis on empirical power correlations

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1									2	1	
CO2	3	3	3	2									1	3	1
CO3	3	3	3	2									2	2	3
CO4	3	3	3	2									2	2	3

Unit 1

Properties and handling of particulate solids- characteristics of solid particles, standard screen series, mixed particle size and screen analysis, effectiveness and capacity of screens, Transportation and storage of solids: bins, hoppers and silos, flow out of bins; conveyor selection, different types of conveyers and their performance characteristics. Comminution of solids (Size Reduction): comminution laws: Kick's law, Rittinger's law and Bond's law and their limitations. Crushing efficiency & power consumption, size reduction equipment, closed circuit and open circuit operation.

Unit 2

Separation of solids: gravity settling, sedimentation, thickening, elutriation, double cone classifier, rake classifier, bowl classifier. Centrifugal separation - continuous centrifuges, bowl classifier, super centrifuges, design of basket centrifuges; Industrial dust removing equipment - cyclones and hydro cyclones, with special reference to electrostatic and magnetic separators; Heavy media separations, floatation. Mixing and Agitation: Mixing of liquids (with or without solids), mixing of liquids (with solids), mixing of liquids (with solids), mixing of powders, selection of suitable mixers, power requirement for mixing

Unit 3

Filtration: Principle of Cake filtration, Pressure drop through filter media, compressible and incompressible filter cakes, Constant pressure and rate filtration, Continuous filtration, washing of filter cakes; Filtration – Theory, Filtration considerations, Batch and continuous filtration equipment (Pressure and Vacuum) – selection, operation and design of filters and optimum cycle of operation.

Textbook(s)

1. W.L. McCabe, J.C. Smith, and P. Harriot, “Unit Operations in Chemical Engineering, 6th Edition, McGraw-Hill, 2001.
2. W.L. Badger and J.T. Banchero, “Introduction to Chemical Engineering“, Tata McGraw Hill, 1997.
3. A.S. Foust, L.A. Wenzel, C.W. Clump, L. Naus, and L.B. Anderson, “Principles of Unit Operations“, 2nd Edition, John Wiley & Sons, 1994.

Reference(s)

1. J.M. Coulson and J.F. Richardson, “Chemical Engineering Vol. I“, 4th Edition, Asian Books Pvt Ltd., India, 1998.

23CHE204 FLUID AND PARTICLE MECHANICS L-T-P-C: 3-1-0-4

Pre-Requisite(s): None

Course Objectives:

The objective of the course is to introduce fundamental aspects of fluid properties and flow behaviour, to develop steady state mechanical energy balance equation for fluid flow systems, and estimate pressure drop in fluid flow systems. The course also focusses on apply fluid mechanics concepts to chemical process industries including selecting suitable flow measuring devices, fluid moving machineries and distinguish the different types of valves used in process industries, pipe flow, packed bed and fluidized bed.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Apply the basic fluid properties and fluid statics principles in practical situations.
CO2:	Interpret the basic fluid kinematic principles for formulating a mathematical description of fluid-flow system.
CO3:	Solve pipe network problems for laminar and turbulent systems by calculating the pressure drop and velocity distribution.
CO4:	Examine the fluid flow fluidized bed and a packed bed by performing pressure drop analysis.
CO5:	Select valves, pumps and flow measuring devices in process industries with the knowledge of the basic principles.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	1								2	3	3	1
CO2	3	3	3	3								2	3	3	1
CO3	3	3	3	3								2	3	3	1
CO4	3	3	3	3								2	3	3	1
CO5	3	2										2	3	3	1

Syllabus

Unit 1

Elementary concepts – Definition of fluid, Continuum mechanics, basic physical properties of fluids, Rheological Classification of fluids, Concept of gauge and absolute pressure, Pascal's law, hydrostatic equilibrium in gravity and centrifugal field, barometric equation, measurement of pressure using manometers of different types.

Introduction to fluid flow: flow field, Eulerian and Lagrangian approach, flow types - Unsteady, Steady and non-uniform, laminar and turbulent flows –Reynolds number; Ideal flow – rotational and irrotational, stream function, potential function – Velocity vectors; Path line, streak line and stream line; Application of one dimensional steady flow; circulation and vorticity; Significance of dimensionless numbers; Dimensional analysis and model testing –Bucking ham pi-theorem;

Unit 2

Derivation of continuity and momentum balance equation for three dimensional flows, boundary conditions, Bernoulli's equation, kinetic energy correction factor, Correction for fluid friction, Pump work, and compressible flow in Bernoulli's equation, Laminar flow through circular pipe – Shear stress and velocity profiles; pressure gradient; Concept of friction and friction factor from drag on a flat plate; Friction loss in laminar and turbulent flows, Minor losses – Pipe fittings and pipe networks, equivalent length for pipe in pipe fittings; Turbulent flow of incompressible fluids in pipes and conduits: Universal velocity distribution equation, Friction factor and Reynolds number relationship, Friction factor chart, Velocity profile in turbulent flows;

Laminar flow between parallel plates – Taylor-Coutte flow and Poiseulle flow; Flow in closed conduits Two dimensional flows - Boundary layer; Boundary layer equation; Blasisus solution for boundary layer flow; boundary layer separation and its control. Application of Bernoulli's equations to flow meters- Pitot tube, Nozzle, Venturi meter and Orifice meter; Coefficient of discharge for flow meters and velocity measurement.

Unit 3

Flow past immersed bodies – drag and lift, drag and lift coefficients, flow though beds of solids, one dimensional motion of particle through fluid, terminal velocity, hindered settling, Pressure drop through porous media for spherical and non-spherical particles – Hydraulic radius of porous medium, Porous medium Reynolds number, Ergun equation; Fluidization – Conditions for onset of fluidization, minimum fluidization velocity; Types of fluidization

Transportation of fluids – pipes, fittings, valves; Pump terminology –Suction and Delivery heads, Suction lift, Cavitation, Net positive suction head and Power requirement; Positive displacement pumps – Reciprocating pump and gear pump; Rotary pumps - Centrifugal Volute pump, Pressure raise in centrifugal pump; Pump characteristics;

Pipe and tubing, Joints and fittings, Valves (diagram and operation of Gate valves and globe valves, diaphragm valves, butterfly valve and ball valves, Check valves).

Textbook(s)

1. Warren L. McCabe, Jullian Smith C. and Peter Harriott, Unit Operations of Chemical Engineering, McGraw-Hill, New York, 2001.
2. De Nevers N H, Fluid Mechanics for Chemical Engineers, McGraw Hill, NY, 1991.
3. Cengel Y.A., and Cimbala J.H, Fluid Mechanics: Fundamentals and Applications, McGraw Hill Publishers, 3rd Edition,, 2013

Reference(s)

1. Coulson J M and Richardson J F, Chemical Engineering, Vol. I and II, Pergamon Press, NY, 1990.
2. John F.Douglas, Fluid Mechanics, Fifth edition, Prentice Hall, 2005
3. Holland F.A., and Bragg R., Fluid Flow for Chemical Engineers, Butterworth Heinmann, 2nd Edition,, 2002
4. Ron Darby, Chemical Engineering Fluid Mechanics, Marcel Dekker Inc., 2nd Edition,, 2001
5. Frank M. White, Fluid Mechanics, McGraw Hill Inc., 4th Edition, 2011
6. R.B. Bird, W.E. Stewart and E.W. Lightfoot, Transport Phenomena, 2nd Edition, John Wiley, 2002
7. Y. Nakayama, Fluid mechanics. Butterworth-Heinemann.

23CHE281 **INDUSTRIAL CHEMICAL TECHNOLOGY LABORATORY** **L-T-P-C: 0-0-3-1**

Pre-Requisite(s): None

Course Objectives

Students will learn how to perform accurate analytical/quantitative measurements by using equipment / instruments.

Course Outcomes

CO1:	Investigate the factors that influence the experiments
CO2:	Examine the properties of materials/products in relation to their performance
CO3:	Perform laboratory experiments in a team and gain experience in teamwork

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2		2	3				3	3			3	2	3
CO2	2	3		3	2				2	2			2	3	3
CO3	3	3		3	3				3	2			3	3	2

Syllabus

List of experiments

1. Determination of the percentage of available chlorine in the given water sample
2. Estimation of saponification value of different oils
3. Analysis of flash point/fire point of given oil
4. Determination of oil viscosity by red wood viscometer
5. Estimation of silica and moisture content in cement
6. Estimation of mixed oxide content in cement
7. Determination of sucrose content in the given sample of sugar
8. Analysis of the percentage of ash and lactose content in the milk sample.
9. Determination of acid value and iodine value of oil
10. Determination of alkalinity and total fatty matter content in the given soap sample
11. Preparation and analysis of chemicals
12. Calorimetry study
13. Composition analysis of gaseous samples

22ADM211 LEADERSHIP FROM RAMAYANA L-T-P-C: 1-0-0-1

Course Objectives:

Through a study of the Rāmāyaṇa, the student should gain a deeper understanding of the ethical grandeur of Indian culture, and be inspired to follow the ideals of the characters depicted therein.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Appreciate the significance of *Rāmāyaṇa* as an *itihāsa,* and important aspects of *Bālakāṇḍa*.
CO2:	Understand the family values and ideal human relationships portrayed in the *Ayodhyakāṇḍa* and *Aranyakāṇḍa* of *Rāmāyaṇa*.
CO3:	Understand *dharma* and its nuances, emphasizing its applicability in an individual's life through *Kishkindhakāṇḍa* and *Sundarakāṇḍa* of Ramayana.
CO4:	Appreciate the triumph of *dharma* over *adharma* through *Yuddhakāṇḍa* of *Rāmāyaṇa*
CO5:	Appreciate the spiritual values from *Rāmāyaṇa* in resolving personal and social conflicts through varied effective presentations of important episodes of the *Rāmāyaṇa.*

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	**Program Outcomes [POs]**												**Program Specific Outcomes [PSOs]***		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO01						2	2	3	3	3		3			
CO02						3	3	3	3	2		3			
CO03						3	2	3	3	3		3			
CO04						3	-	3	3	3		3			
CO05						3	-	3	3	2		3			

Syllabus

Unit 1

An overview of Valmiki's epic. Introdcution to the content and structure of the epic text and it's principal characters.

Bala-Kāṇḍa: Preparing for the renowned mission.

Unit 2

Ayodhya-Kāṇḍa: Harbinger of an Entire Tradition of Nobleness.

Araṇya-Kāṇḍa: Tale of the forest life.

Unit 3

Kishkindha-Kāṇḍa: The Empire of Holy Monkeys.

Sundara-Kāṇḍa: Heart of the Ramayana

Unit 4

Yuddha-Kāṇḍa:The most popular part of the Ramayana

Uttara-Kāṇḍa: An attempt to explain the untold stories.

Unit 5

Ramayana and Modern-day learning

Ecological Awareness in the Ramayana

Different Ramayana: Epic that connects the world.

Textbook / Reference(s)

1. *Leadership Lessons from the Ramayan*a, ASCSS
2. Rajagopalachari. C, *The Ramayana*
3. Valmiki, *The Ramayana*, Gita Press

23LAW300 **INDIAN CONSTITUTION** **L-T-P-C: P/F**

Course Objectives:

• To know about Indian constitution
• To know about central and state government functionalities in India
• To know about Indian society

Syllabus

Unit 1:
Historical Background – Constituent Assembly Of India – Philosophical Foundations Of The Indian Constitution – Preamble – Fundamental Rights – Directive Principles Of State Policy – Fundamental Duties – Citizenship – Constitutional Remedies For Citizens.

Unit 2:
State Government – Structure and Functions – Governor – Chief Minister – Cabinet – State Legislature – Judicial System in States – High Courts and other Subordinate Courts.

Unit 3:
State Government – Structure and Functions – Governor – Chief Minister – Cabinet – State Legislature – Judicial System in States – High Courts and other Subordinate Courts.

Textbook(s)
1. *Durga Das Basu, "Introduction to the Constitution of India ", Prentice Hall of India, New Delhi.*
2. *R.C.Agarwal, (1997) "Indian Political System", S.Chand and Company, New Delhi.*

Reference(s)
1. *Sharma, Brij Kishore, "Introduction to the Constitution of India", Prentice Hall of India, New Delhi.*

23LSE201	Life Skills for Engineers I	L-T-P-C: 1-0-2-P/F

Pre-requisite: An open mind and the urge for self-development, basic English language skills, knowledge of high school level mathematics.

Course Objectives
- Assist students in inculcating Soft Skills and developing a strong personality
- Help them improve their presentation skills
- Support them in developing their problem solving and reasoning skills
- Facilitate the enhancement of their communication skills

Course Outcomes
CO1 - Soft Skills: To develop greater morale and positive attitude to face, analyse, and manage emotions in real life situations, like placement process.

CO2 - Soft Skills: To empower students to create better impact on a target audience through content creation, effective delivery, appropriate body language and overcoming nervousness, in situations like presentations, Group Discussions and interviews.
CO3 - Aptitude: To analyze, understand and employ the most suitable methods to solve questions on arithmetic and algebra.
CO4 - Aptitude: To investigate and apply suitable techniques to solve questions on logical reasoning and data analysis.
CO5 - Verbal: To infer the meaning of words and use them in the right context. To have a better understanding of the basics of English grammar and apply them effectively.
CO6 - Verbal: To identify the relationship between words using reasoning skills. To develop the capacity to communicate ideas effectively.

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1								2	3	3		3
CO2									2	3		3
CO3		3		2								
CO4		3		2								
CO5										3		3
CO6									3	3		3

Syllabus

Soft Skills

Soft Skills and its importance: Pleasure and pains of transition from an academic environment to work-environment. New-age challenges and distractions. Learning to benefit from constructive criticisms and feedback, Need for change in mindset and up-skilling to keep oneself competent in the professional world.
Managing Self: Knowing oneself, Self-perception, Importance of positive attitude, Building and displaying confidence, Avoiding being overconfident, Managing emotions, stress, fear. Developing Resilience and handling failures. Self-motivation, Self-learning, and continuous knowledge up-gradation / Life-long learning. Personal productivity - Goal setting and its importance in career planning, Self-discipline, Importance of values, ethics and integrity, Universal Human Values.

Aptitude

Problem Solving I
Numbers: Types, Power Cycles, Divisibility, Prime, Factors & Multiples, HCF & LCM, Surds, Indices, Square roots, Cube Roots and Simplification.
Percentage: Basics, Profit, Loss & Discount, and Simple & Compound Interest.
Ratio, Proportion & Variation: Basics, Alligations, Mixtures, and Partnership.
Averages: Basics, and Weighted Average.
Data Interpretation: Tables, Bar Diagrams, Venn Diagrams, Line Graphs, Pie Charts, Caselets, Mixed Varieties, Network Diagrams and other forms of data representation.

Verbal

Vocabulary: Familiarize students with the etymology of words, help them realize the relevance of word analysis and enable them to answer synonym and antonym questions. Create an awareness about the frequently misused words, commonly confused words and wrong form of words in English.
Grammar (**Basic**): Help students learn the usage of structural words and facilitate students to identify errors and correct them.
Reasoning: Stress the importance of understanding the relationship between words through analogy questions.
Speaking Skills: Make students conscious of the relevance of effective communication in today's world through various individual speaking activities.

References:

1. Students" Career Planning Guide, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
2. Soft Skill Handbook, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
3. Adair. J., (1986), "Effective Team Building: How to make * winning team", London, U.K
4. Gulati. S., (1006) "Corporate Soft Skills", New Delhi, India: Rupa & Co.
5. The hard truth about Soft Skills, by Amazon Publication.
6. Verbal Skills Activity Book, CIR, AVVP
7. English Grammar & Composition, Wren & Martin
8. Nova's GRE Prep Course, Jeff Kolby, Scott Thornburg & Kathleen Pierce
9. Cracking the New GRE 2012
10. Kaplan's – GRE Comprehensive Programme
11. Student Workbook: Quantitative Aptitude & Reasoning, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
12. Quantitative Aptitude for All Competitive Examinations, Abhijit Guha.
13. How to Prepare for Quantitative Aptitude for the CAT, Arun Sharma.
14. How to Prepare for Data Interpretation for the CAT, Arun Sharma.

Evaluation Pattern

Assessment	Internal	External
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25
Continuous Assessment (CA)* – Verbal	10	25
Total	50	50
Pass / Fail		

*CA - Can be **presentations, speaking activities and tests.**

SEMESTER 4

23CHE211	CHEMICAL ENGINEERING THERMODYNAMICS	L-T-P-C: 3-0-0-3

Pre-Requisite(s) : Energy balance and Thermodynamics

Course Objectives

The objective of the course is to understand the significance of thermodynamic potentials, thermodynamic property relations and illustrate their applications in evaluation of departure functions, solution properties, VLE calculations and chemical reaction equilibria

Course Outcomes

After the completion of this course, student will be able to

CO1:	Evaluate the thermodynamic properties of pure fluids from measurable quantities like P-V-T and analyze the deviation from ideal behavior
CO2:	Estimate the phase of a given substance (pure/mixture) at a given P-T values based on equation of state and excess properties
CO3:	Estimate vapor and liquid compositions using VLE for ideal and non-ideal solutions and analyze the effect of P and T during flash separation.
CO4:	Evaluate the conversion at equilibrium and to predict the effect of controllable variables like temperature and pressure on the conversion.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	-	-	-	-	-	-	-	-	3	2	-
CO2	3	3	2	3	-	-	-	-	-	-	-	-	3	2	-
CO3	3	3	2	3	-	-	-	-	-	-	-	-	3	2	-
CO4	3	3	2	2	-	-	-	-	-	-	-	-	3	2	-

Syllabus

Unit 1

Pure gaseous substances-P-v-T behavior of pure substances, Calculation of work done, heat transferred, change in enthalpy in different processes-Ideal and non ideal gases, Equation of state, Compressibility factor
Gas mixtures-P-v-T behavior of gas mixtures, Ideal and non ideal mixtures, Mixture rules, Compressibility factor for mixtures. Excess properties of mixtures-Temperature and Pressure dependence, Gibbs- Duhem equation. Estimation of different thermodynamic properties for pure components and mixtures.

Unit 2

Ideal and non ideal solutions; vapor pressure of solutions; fugacity and activity coefficients and their estimation; Criterion for vapor liquid equilibrium (VLE); Binary VLE-Bubble and dew point calculations. Equation of state and Activity coefficient models; Multi component VLE-K factor approach; Thermodynamic consistency of VLE data. Criterion for liquid- liquid equilibrium; Estimation of distribution coefficient from activity models. Composition estimation in problems related to extraction

Unit 3

Criterion for chemical reaction equilibrium-feasibility of chemical processes, Equilibrium constant.

Conversion calculations in a reaction-Homogeneous gas phase reactions, Gas liquid reactions, effect of temperature and pressure on conversion

Textbook(s)

1. Y.V.C Rao , Chemical Engineering Thermodynamics, React1st Edition, 2001
2. J. P. O’Connell and J M Haile, Thermodynamics: Fundamentals for Applications, Cambridge University Press,2005.
3. Yunus A Cengel, Thermodynamics: An Engineering Approach,7th Edition,2010.

Reference(s)

1. K.A Gavhane, Chemical Engineering Thermodynamics,4th edition,2015
2. KV Narayanan, Chemical Engineering Thermodynamics,2nd edition,2013.
3. J.M Smith, H C Van Ness, M M Abbott, Introduction to Chemical Engineering Thermodynamics, 2010.

23MAT213 FOUNDATIONS OF DATA SCIENCE L-T-P-C: 2-1-0-3

Course Objectives:

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Understand various the data visualization methods.
CO2:	Understand the basics of the descriptive statistics.
CO3:	Understand and apply the basic concepts of correlations and regressions to the given data.
CO4:	Understand and apply the basic concepts of sampling techniques and simple hypothetical testing to the given data.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO01	3	2		2	2						2	2			
CO02	3	2		3	2						2	2			
CO03	3	3		3	2						3	3			
CO04	3	3		3	3						3	3			

Syllabus

Unit 1

Introduction, Causality and Experiments, Data Preprocessing: Data cleaning, Data reduction, Data transformation, Data discretization. Visualization and Graphing: Visualizing Categorical Distributions, Visualizing Numerical Distributions, Overlaid Graphs, plots, and summary statistics of exploratory data analysis, Randomness, Probability, Introduction to Statistics, Sampling, Sample Means and Sample Sizes. (15 hrs)

Unit 2

Descriptive statistics – Central tendency, dispersion, variance, covariance, kurtosis, five point summary, Distributions, Bayes Theorem, Error Probabilities; Permutation Testing, Statistical Inference; Hypothesis Testing, Assessing Models, Decisions and Uncertainty, Comparing Samples, A/B Testing, P-Values, Causality. (15 hrs)

Unit 3

Estimation, Prediction, Confidence Intervals, Inference for Regression, Classification , Graphical Models, Updating Predictions. (15 hrs)

Textbook(s)

1. Adi Adhikari and John DeNero, "Computational and Inferential Thinking: The Foundations of Data Science", e-book.

Reference(s)

1. Data Mining for Business Analytics: Concepts, Techniques and Applications in R, by Galit Shmueli, Peter C. Bruce, Inbal Yahav, Nitin R. Patel, Kenneth C. Lichtendahl Jr., Wiley India, 2018.
2. Rachel Schutt & Cathy O'Neil, "Doing Data Science" O' Reilly, First Edition, 2013.

23CHE212 STRENGTH OF MATERIALS L-T-P-C: 3-0-0-3

Pre-Requisite: Statics

Course Objectives

The objective of the course is to impart the concept of stresses and strains on elastically deformable members subjected to axial, bending, and torsional loads. The course discusses in detail, the shear force bending momentson beams, bending stresses, and stresses developed in pressure vessels.

Course Outcomes

After the completion of this course, student will be able to

CO1:	Determine the types of stresses, strain and moduli in solids subjected to elastic deformation.
CO2:	Draw shear force, bending moment diagrams and estimate bending stresses developed in beams.
CO3:	Solve problems in cylindrical and spherical shells , columns under compression, and shafts subjected to pure torsion.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1									2	1	
CO2	3	3	3	2									1	3	1
CO3	3	3	3	2									2	2	3
CO4															
CO5															

Syllabus

Unit 1

Simple Stresses and Strains: Hooke's law-Elastic limit, tension, compression and shear stresses- Stiffness - Poisson's ratio - Analysis of varying sections -bars of composite sections – Thermal stresses, Complex stresses.

Unit 2

Shear force and bending moment: Different types of support conditions and loads-Cantilever – simply supported – Overhanging beams, point loads, uniformly distributed loads-Theory of Simple bending; flexural formula analysis of stresses in beams – load carrying capacity of beams -Deflection of beams

Unit 3

Torsion of circular sections ; Derivation of torsional formula –Power transmitted – Solid and hollow shafts. Thin Shells; Thin cylindrical shells subjected to internal pressure – Circumferential stress – Longitudinal stress – change in diameter – length-volume – Thin spherical shells. Columns; Axially loaded Columns – Different end conditions – Euler's formula for long columns.

(Free softwares which graphically depicts the direction of internal stresses, applied loads, and reaction forces can be used for developing problem solving skills of the students)

Textbook(s)

1. R.C. Hibbeler, Statics and Mechanics of Materials, Prentice Hall, 2013

Reference(s)

1. F.P. Beer, E.R. Johnston & D. Mazurek, Vector Mechanics for Engineers: Statics, McGraw-Hill Higher Education, 2012.
2. J.M. Gere and B.J. Goodno, Mechanics of Materials, CL Engineering, 2012.

23CHE213 PROCESS HEAT TRANSFER L-T-P-C: 3-1-0-4

Pre-Requisite(s) : None

Course Objectives

The objective of the course is to impart knowledge on fundamental concepts of heat transfer relevant to Chemical Engineering. The course inculcates the ability to apply the fundamental principles of heat transfer to thermal systems/heat transfer unit operations.

Course Outcomes

After the completion of this course, student will be able to

CO1:	Describe the basic principles of conductive, convective, and radiative modes of heat transfer
CO2:	Analyze thermal systems using basic principles of heat transfer and energy balance
CO3:	Analyze Heat Exchangers, Evaporators and Condensers using basic principles of heat transfer, energy balance, and mass balance

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1												1		
CO2	3	1	1										2		
CO3	3	2	2										3		

Syllabus

Unit 1
Modes of heat transfer: Introduction to Conduction, convection, radiation and the laws governing them; Material properties of importance for heat transfer; Conduction in regular bodies: Slab, cylinder, and sphere; Convective heat transfer: Heat transfer coefficient (individual and overall), Extended Surface, Critical insulation for cylinder and sphere; Heat Transfer in forced laminar flow: Laminar flow over horizontal flat plate, flow through pipe, flow over cylinders and spheres

Unit 2
Heat transfer in forced turbulent flow: Analogies for heat transfer coefficient, Reynold's analogy, Chilton-Colburn analogy, Prandtl analogy, Von Karman analogy; Simultaneous heat and mass transfer: Principles and introduction to applications; Unsteady state heat transfer with convection: Cartesian, Cylindrical, and Spherical coordinate system; Lumped Capacity Model; Solution to Heat Equation: Introduction to Fourier Series; Radiation: View Factor, Heat Transfer Between Surfaces.

Unit 3
Heat transfer with phase change: Stages in boiling, boiling curve, heat transfer during condensation Heat Exchangers: Double pipe heat exchanger, LMTD method, Effectiveness – NTU method, Shell and Tube Heat

Exchanger, Types of Heat Exchangers, Selection of Heat Exchangers, Design Principle; Evaporators: Single and Multiple Effect Evaporators, Design principle, Types of evaporators; Condensers: Design Principle, Types of Condensers.

Textbook(s)

1. J. P. Holman, Heat Transfer, 10^{th} edition, McGraw Hill, International Edition, 2010
2. D.Q. Kern, Process Heat Transfer, McGraw Hill

Reference(s)

1. McCabe, Smith, and Harriott, Unit Operations in Chemical Engineering, 6th Edition, McGraw Hill, International Edition, 2001
2. Binay K Datta, Heat Transfer – Principles and Applications, PHI Learning Pvt Ltd, 2001
3. J. R. Welty et al., Fundamentals of Momentum, Heat and Mass Transfer, 4th Edition, Wiley, 2000.

23CHE214 PROCESS INSTRUMENTATION L-T-P-C: 3-0-0-3

Pre-Requisite(s) : None

Course Objectives

The objective of the course is to provide an introduction to the field of Instrumentation covering process variables and the various instruments used to sense, measure, transmit and control these variables.

Course Outcomes

After the completion of this course, student will be able to

CO1:	Describe general principles of measurement, measurement methods employed in industrial processing and manufacturing, various elements of instrumentation, static and dynamic characteristics of instruments, calibration methods of instruments to perform error analysis.
CO2:	Describe the operating principles, construction & working of temperature measuring devices and gain ability to select the most suitable measuring device based on its performance characteristics.
CO3:	Explain operating principles, construction & working of pressure, flow and level measuring devices.
CO4:	Enumerate working principles of various analytical instruments and online instrumentation measuring viscosity, pH, moisture, composition analysis etc.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2										3	1	1
CO2	3	2	2										3	1	1
CO3	3	2	2										3	1	1
CO4	3	2	2										3	1	1

Syllabus

Unit 1

Introduction, general principles of measurement, classification of instruments, elements of an instrument, direct and inferential measurement; Static and dynamic characteristics of instruments, errors in measurements & error analysis; Classification of sensors and transducers, amplifier signal conditioner, signal isolation, transmission, display, data acquisition modules, interfaces, recording. Control centre, instrumentation diagram. Methods for Selection of Measuring Instruments.

Temperature measurement: Expansion thermometers - constant-volume gas thermometer, pressure spring thermometer, volumetric and pressure thermometers; Thermoelectric temperature measurement - Thermoelectricity, industrial thermocouples; Resistance thermometers -industrial resistance thermometers, null-bridge resistance thermometers, deflectional resistance thermometers; Radiation temperature measurement -radiation pyrometers, photoelectric pyrometers and optical pyrometers.

Unit 2

Measurement of pressure and vacuum: Pressure, vacuum and head; liquid column manometers - U-tube type, well type and inclined type, micromanometers; Low pressure measurement - kenetometer, McLeod gage, thermal conductivity gauge; Barometer method for atmospheric pressure measurement; pressure measurement using bourdon tube, flat and corrugated diaphragms, and capsules; Measurement of pressure in corrosive fluids using liquid seal and diaphragm seal. Hydrostatic type, Elastic Element type, Electrical Type and other type of instruments like McLeod Gauge, Thermocouple gauge, Knudson Gauge, Ionization Gauge.

Flow measurement : Variable area and variable head flow meters, volumetric and mass flow rate meters, linear velocity measurement systems, anemometers; Measurement of Head and Level:Density and specific gravity - constant volume hydrometer, air pressure balance method, gas density detector and gas specific gravity measuring system; Level measurement : pressure type , resistance & capacitance type, sonic & ultrasonic, thermal type level meters, level measurement in open vessels and in pressure vessels, solid level detectors.

Unit 3

Viscometers: Redwood, Saybolt, Engler, Cup and Cone type, Rheo & other types of viscometers; Composition analysis -Gas analysis by thermal conductivity, analysis of moisture in gases (humidity), psychrometer method, hygrometer method, dew point method for moisture analysis in gases, measurement of moisture solids; pH measurement; Gas analysis by thermal conductivity, polarography & chromatography; Composition analysis using spectroscopic methods;

On line instrumentation in modern plants. IoT in instrumentation and measurement; its advantages, and challenges; case studies.

Textbook(s)

1. Jain R.K., Mechanical and Industrial Measurements, Khanna

Reference(s)

1. Ernest O. Doebelin, “Measurements systems Application & design”, McGraw Hill Publishing, 1990.
2. T. G. Beckwith, R.D. Marangoni and J. H. Lienhard, “Mechanical Measurements”, 6th Edn, Prentice Hall, 2006.
3. Eckman D.P., Industrial Instrumentation, Wiley Eastern
4. Patranabis, D., “*Principles of Industrial Instrumentation*” 2nd ed. Tata McGraw Hill, New Delhi.
5. Boon-Yaik Ooi and Shervin Shirmohammadi, “The Potential of IoT for Instrumentation and Measurement” 2020, IEEE Instrumentation & Measurement Magazine 21 1094-6969/20/$25.00©2020IEEE.
6. Toteva, Pavlina, et. al. 2014, Applied Mechanics and Materials 657:1006-1010, DOI: 10.4028/www.scientific.net/AMM.657.1006

23CHE282 **SOLID AND FLUID OPERTAIONS LABORATORY** **L-T-P-C: 0-0-3-1**

Prerequisite: Solid and Fluid Operations

Course Objectives

The course aims to develop hands-on particle characterization, specific surface area and size reduction ratio estimation. Emphasis is also on operating various size reduction and filtration equipment used in chemical industries.

Course Outcomes

After the completion of this course, student will be able to

CO 1:	Determination of particle diameter and specific surface area estimation by differential and cumulative analysis
CO 2:	Estimation of power consumption in Jaw, Roll, and Drop Weight Crushers and Ball Mill
CO 3:	Develop proficiency in the comparison of actual and ideal screens and in the operation of cyclone separator
CO4:	Build expertise in operating dewatering equipment such as Filter Press and Leaf Filter for determination of cake resistance

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	2									1	2	2
CO2	2	3	2	2									1	2	2
CO3	3	3	3	2									3	3	3
CO4	3	3	3	3									3	3	3

Syllabus:

List of experiments

1. Particle Characterisation by Sieve analysis
2. Screen efficiency using Screen Effectiveness
3. Energy consumption and Reduction Ratio in size reduction equipment like Jaw crusher, Ball mill and Roll Crusher
4. Particle Separation using Cyclone Separator
5. Reduction ratio in Drop Weight Crusher
6. Thickener Area in Sedimentation
7. Cake Resistance in Plate and frame filter
8. Cake Resistance in Vacuum filter

9. Flux determination and Performance Evaluation in Ultrafiltration/Microfiltration
10. Flux determination and Performance Evaluation in Nanofiltration/Reverse Osmosis

Textbook(s)

1. McCabe W.L., Smith J.C. and Harriot P., Unit Operations of Chemical Engineering McGraw Hill, New York 2001. 6th Edition
2. Chattopadhyay O.P., Unit Operations of Chemical Engineering, Vol. 1 & 2, Khanna Publications, New Delhi, 1996.
3. Coulson J. M. and Richardson J.F; Chemical Engineering Vol. 1& 2 Publishers: Butter worth – Heinemann Ltd. 2001-2002.
4. Christie J. GeanKoplis Transport processes & Unit Operation Prentice hall international
5. Badger & Banchero Introduction to Chemical Engineering Mc-Graw- Hill Education
6. G.G. Brown Unit Operation John Willey
7. Hiremath R.S & Kulkarni A.P. Mechanical Operations Vol I Everest Publication

23CHE283 FLUID MECHANICS LABORATORY L-T-P-C : 0-0-3-1

Pre-Requisite(s) : Fluid and Particle Mechanics

Course Objectives

To develop ability to do chemical engineering experiments related to fluid dynamics.

Course Outcomes

At the end of the course students would be able to:

CO1:	Estimate the coefficient of discharge for venturi meter, orifice meter and rotameter using Bernoulli's principle
CO2:	Estimate the friction losses in packed column, helical coil and annular pipes based on the flow regime using appropriate flow equations
CO3:	Plot the performance characteristic curves for centrifugal and reciprocating pumps using experimental measurements
CO4:	Compare the drag coefficients of free falling bodies in columns of two different liquids using stokes law

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				2	3	2			3	3	3
CO2	3	3	3	3				2	3	2			3	3	3
CO3	3	3	3	3				2	3	2			3	3	3
CO4	3	3	3	3				2	3	2			3	3	3
CO5															

Syllabus

List of experiments

- Flow through Venturi meter
- Flow through orifice meter
- Flow through rotameter
- Friction loss in pipe flow
- Performance test on centrifugal pump
- Performance test on reciprocating pump
- Flow through helical coil pipe
- Flow through annular pipe
- Drag reduction studies
- Flow through packed bed
- Study of flow through microchannels

22ADM201	**STRATEGIC LESSONS FROM MAHABHARATA**	**L-T-P-C: 1-0-0-1**

Course Objectives:

Through a study of the Mahabharata, the student should gain a deeper understanding of the ethical grandeur of Indian culture, and be inspired to follow the ideals of the characters depicted therein.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Understanding the impact of itihasas on Indian civilization with a special reference to the Adiparva of Mahabharata.
CO2:	Enabling students to importance of fighting adharma for the welfare of the society through Sabha and Vanaparva.
CO3:	Understanding the nuances of dharma through the contrast between noble and ignoble characters of the epic as depicted in the Vana, Virata, Udyoga and Bhishma parvas.
CO4:	Getting the deeper understanding of the Yuddha Dharma through the subsequent Parvas viz., Drona, Karna, Shalya, Sauptika Parvas.
CO5:	Making the students appreciative of spiritual instruction on the ultimate triumph of dharma through the presentations of the important episodes of the MB with special light on Shanti, Anushasana, Ashwamedhika, Ashramavasika, Mausala, Mahaprasthanika and Swargarohana Parvas.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO01						1	-	3	1	-		3			
CO02						2	3	3	3	3		3			
CO03						3	3	3	3	3		3			
CO04						3	-	3	3	2		3			
CO05						3	1	3	1	1		3			

Syllabus

Unit 1
Introduction and Summary of the Mahabharata

A Preamble to the Great Itihasa

Unbroken Legacy

Unit 2

Dharmic Insights of a Butcher
The Vows We Take
Kingship and Polity Acumen

Unit 3
Karna – The Maestro that Went Wide off the Mark
Tactics of Krishna
Yajnaseni

Unit 4
Popular Regional Tales
Maha Prasthanam – The Last Journey.

Unit 5
Mahabharata - An All-Encompassing Text
Mahābhārata- Whats and WhatNots
Nyayas in Mahabharata

Textbook(s) / Reference(s)

1. *Leadership Lessons from the Mahabharat*, ASCSS
2. Rajagopalachari. C, *The Mahabharata*

23LSE211	**Life Skills for Engineers II**	**L-T-P-C: 1-0-2-2**

Pre-requisite: An inquisitive mind, basic English language skills, knowledge of high school level mathematics.

Course Objectives

- Assist students in inculcating Soft Skills and developing a strong personality
- Help them improve their presentation skills
- Aid them in developing their problem solving and reasoning skills
- Facilitate them in improving the effectiveness of their communication

Course Outcomes

CO1 - Soft Skills: To develop greater morale and positive attitude to face, analyse, and manage emotions in real life situations, like placement process.
CO2 - Soft Skills: To empower students to create better impact on a target audience through content creation, effective delivery, appropriate body language and overcoming nervousness, in situations like presentations, Group Discussions and interviews.
CO3 - Aptitude: To analyze, understand and employ the most suitable methods to solve questions on arithmetic and algebra.

CO4 - Aptitude: To investigate and apply suitable techniques to solve questions on logical reasoning and data analysis.
CO5 - Verbal: To learn to use more appropriate words in the given context. To have a better understanding of the nuances of English grammar and become capable of applying them effectively.
CO6 - Verbal: To be able to read texts critically and arrive at/ predict logical conclusions. To learn to organize speech and incorporate feedback in order to convey ideas with better clarity.

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1								2	3	3		3
CO2									2	3		3
CO3		3		2								
CO4		3		2								
CO5										3		3
CO6									3	3		3

Syllabus

Soft Skills

Communication: Process, Language Fluency, Non-verbal, Active listening. Assertiveness vs. aggressiveness. Barriers in communication. Digital communication
Presentations: Need, importance, preparations, research and content development, structuring and ensuring flow of the presentation. Ways and means of making an effective presentation: Understanding and connecting with the audience – using storytelling technique, managing time, appropriate language, gestures, posture, facial expressions, tones, intonations and grooming. Importance of practice to make an impactful presentation.

Aptitude

Problem Solving II
Equations: Basics, Linear, Quadratic, Equations of Higher Degree and Problems on ages.
Logarithms, Inequalities and Modulus: Basics
Time and Work: Basics, Pipes & Cistern, and Work Equivalence.
Time, Speed and Distance: Basics, Average Speed, Relative Speed, Boats & Streams, Races and Circular tracks.
Logical Reasoning: Arrangements, Sequencing, Scheduling, Venn Diagram, Network Diagrams, Binary Logic, and Logical Connectives.

Verbal

Vocabulary: Aid students learn to use their vocabulary to complete the given sentences with the right words. Usage of more appropriate words in different contexts is emphasized.
Grammar (**Basic-intermediate**): Help students master usage of grammatical forms and enable students to identify errors and correct them.
Reasoning: Emphasize the importance of avoiding the gap (assumption) in arguments/ statements/ communication.
Reading Comprehension (**Basics**): Introduce students to smart reading techniques and help them understand different tones in comprehension passages.
Speaking Skills: Make students be aware of the importance of impactful communication through individual speaking activities in class.

Writing Skills: Introduce formal written communication and keep the students informed about the etiquette of email writing.

References:

1. Students" Career Planning Guide, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
2. Soft Skill Handbook, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
3. Adair. J., (1986), *"Effective Team Building: How to make * winning team",* London, U.K
4. Gulati. S., (1006) "Corporate Soft Skills", New Delhi, India: Rupa & **Co.**
5. The hard truth about Soft Skills, by Amazon Publication.
6. Verbal Skills Activity Book, CIR, AVVP
7. English Grammar & Composition, Wren & Martin
8. Nova's GRE Prep Course, Jeff Kolby, Scott Thornburg & Kathleen Pierce
9. Cracking the New GRE 2012
10. Kaplan's – GRE Comprehensive Programme
11. Student Workbook: Quantitative Aptitude & Reasoning, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
12. Quantitative Aptitude for All Competitive Examinations, Abhijit Guha.
13. How to Prepare for Quantitative Aptitude for the CAT, Arun Sharma.
14. How to Prepare for Data Interpretation for the CAT, Arun Sharma.

Evaluation Pattern

Assessment	Internal	External
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25
Continuous Assessment (CA)* – Verbal	10	25
Total	50	50

*CA - Can be **presentations, speaking activities and tests.**

SEMESTER 5

23CHE301 CHEMICAL REACTION ENGINEERING L-T-P-C: 3-1-0-4

Pre-Requisite(s): Chemical Process Calculations, Energy Balance and Thermodynamics, Chemical Engineering Thermodynamics, Process Heat transfer, Calculus

Course Objectives

The students attending the course will learn design reactors for homogeneous reactions, obtain kinetic rate parameters based on the experimental data from reactions conducted in homogeneous reactors. Further, students will also learn how to optimize recycle ratio for autocatalytic reactions and minimize total reactor volume in a multiple reactor system.

Course Outcomes

At the end of the course students would be able to:

CO1:	Estimate the kinetic rate parameters (order, rate constant, activation energy and pre-exponential factors) from the experimental data obtained from batch, mixed flow reactor and plug flow reactors using linear and non-linear regression.
CO2:	Predict the sensitivity of temperature, pressure and composition on the reaction/reactor performance using material and energy balance equations
CO3:	Formulate reaction mechanisms for non-elementary reactions based on experimentally determined rate, pseudo steady state hypothesis and guidelines for reaction mechanism formulation
CO4:	Design reactors for single and multiple homogeneous reactions for a specified conversion, productivity and selectivity using a rate vs. conversion or selectivity vs. conversion relationship
CO5:	Optimize recycle ratio and reactor volume for single and multiple reactions including autocatalytic reactions using design equations for reactors.
CO6:	Design catalysts for heterogeneous reactions to eliminate pore diffusion and external mass transfer resistance using Thiele modulus, internal effectiveness factor, and external effectiveness factor

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	2	3								3	2	
CO2	3	3	3	3	3								3	3	3
CO3	3			3									3	3	3
CO4	3	3	3										3	3	3
CO5	3	3	3		3								3	3	3
CO6		3		3									3		3

Syllabus

UNIT 1

Overview of Chemical Kinetics; Rate mechanism for elementary reactions – analysis of rate mechanism from the order of reaction for a particular species; Analysis of batch reactor data: Evaluation of reaction rate parameters – Integral and differential analysis – their limitations – use Microsoft EXCEL for analysis of batch reactor data; Design of Ideal reactors for isothermal homogeneous reactions: Derivation of performance equations for batch, tubular plug flow and stirred tank reactors – space time and space velocities, size comparison of reactors; The students will also learn effect of catalyst parameters on reactor performance in heterogeneous reactors.

UNIT 2

Reactors choice for single reactions – Reactors in series and in parallel; Effect of recycle on reactor performance; Reactor design for multiple reactions – Series and parallel reactions, selectivity, fractional and overall conversion, choice of contacting pattern for parallel and series reactions, reactor size determination for series and parallel reactions; Effect of pressure drop on reactor performance – Homogenous gas and liquid phase reactions.

UNIT 3

Standard heat of reaction – effect of temperature on heat of reaction, Design of non-isothermal reactions – non-isothermal plug flow reactor and stirred tank reactors, adiabatic reactors, effect of spatial variations of temperature on non-isothermal plug flow reaction, optimization of reactor temperature for gas and liquid phase reactions

Textbook(s)

1. Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, John-Wiley Publishers, 1999
2. Rutherford Aris, Elementary Chemical Reactor Analysis, Butterworths Series in Chemical Engineering, 1989

Reference(s)

1. H.S. Fogler, Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall India, 2000
2. G.F. Froment and K.B. Bischoff, Chemical Reactor Analysis and Design, 2nd Edition, John-Wiley Publishers, 1990

23CHE302 MASS TRANSFER OPERATIONS I L-T-P-C : 3-1-0-4

Pre-Requisite(s): Chemical Process Calculations, Fluid and Particle Mechanics, Chemical Engineering Thermodynamics, Process Heat Transfer

Course Objectives

The objective of the course is to introduce the undergraduate students with the laws of diffusion; convective mass transfer, interphase mass transfer and mass transfer coefficients, mass transfer correlations; mass transfer theories/models. The course will also provide proper understanding of unit operations such as absorption, drying, humidification and dehumidification..

Course Outcomes

After the completion of this course, student will be able to

CO 1:	Comprehend facts related to molecular diffusion, diffusive mass flux, and empirical diffusion correlations.
CO 2:	Acquire basic concepts related to phase equilibria, the solubility of gases in liquids, and interphase mass transfer.
CO 3:	Infer understanding of gas-liquid equilibria with emphasis on absorption and humidification operations.
CO4:	Analyze the mechanism of solid-gas and solid-liquid equilibria in driers and crystallizers

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		1									3		
CO2	3	3	3	2									3	3	
CO3	3	3		3									3		
CO4	3	3		1									3		

Syllabus

Unit 1

Molecular diffusion in fluids, Fick's Law of diffusion, steady state diffusion under stagnant and laminar flow conditions. Diffusivity measurement and estimation, multi-component diffusion, diffusion in solids and its applications, eddy diffusion, mass transfer coefficients, theories of mass transfer, analogy equations, application of empirical correlations to known geometry such as flat plates, wetted wall columns. Concept of mass transfer coefficients, inter phase mass transfer, two film theory, relationship between individual and overall mass transfer coefficients. Mass transfer in fluidized bed, flow past solids and boundary layers. Equipment for countercurrent and concurrent mass transfer operations.

Unit 2

Absorption and stripping – Gas liquid equilibria, Raoult's and Henry's laws, Solubility of gases in liquid, choice of solvent; Material balance in countercurrent and concurrent absorption and stripping, L/G ratio, absorption factor; Equipment for absorption, Graphical and analytical methods for tray column, packed columns for absorption: rate based designs, HTU, NTU and HETP concepts, absorption with chemical reaction. Absorption: Design of tray tower absorbers; Operating characteristics of stagewise and differential contactors; Design calculations for single stage, multistage concurrent and countercurrent absorbers

Unit 3

Humidification and dehumidification: vapour liquid equilibria, theory of wet-bulb temperature and adiabatic saturation temperature, Lewis relation, Lewis relation, psychometric chart, humidification and dehumidification equipment, enthalpy transfer concepts – temperature profiles in humidifier and dehumidifiers theory. Classification and design of cooling towers. Drying: Solid - gas equilibria, mechanism of drying, drying curves, modes of drying operations, classification of dryers, industrial dryers for batch and continuous drying, time of drying in batch operation, estimation of size of rotary dryer based on rate concept.

Textbook(s):

1. R.E. Treybal, Mass Transfer Operations, 3rdEdn. McGraw-Hill 1981.
2. Binay K. Dutta, Principles of Mass Transfer and Separation Processes, PHI Learning Private Ltd, 2013

Reference(s):

1. J.D. Seader, Ernest J. Henley, Separation Process Principles, 2nd Edition, Wiley India, 2011
2. Coulson, J.M. and Richardson, J.F. Chemical Engineering Vol. II, 4thEdn., Asian Books Pvt. Ltd. India. 1998.
3. McCabe, W.L. Smith, J.C. and Harriot, P. “Unit Operations in Chemical Engineering, 6thEdn, McGraw – Hill Edn, 2001.
4. J.R. Welty, C.E Wicks, G.L. Rorrer and R.E. Wilson, Fundamentals of Momentum, Heat and Mass Transfer, 4th Edition, Wiley, 2000.
5. Foust, A.S. Wenzel, L.A. Clump, C.W. Naus, L., and Anderson, L.B. ‘Principles of Unit Operations’, 2ndEdn. Wiley, 1980.
6. Geankoplis, C.J., “Transport Processes and Unit Operations”, 4th Edition,Prentice Hall of India Pvt. Ltd, New Delhi, 2004.

23CHE303 CHEMICAL TECHNOLOGY L-T-P-C : 3-0-0-3

Pre-Requisite(s): Chemical Process Calculations, Energy Balance and Thermodynamics

Course Objectives:

The objective of the course is to understand the manufacturing techniques and process technology involved in the making of chemical and allied products including the development of flowsheet using software.

Course Outcome:

After this course, students will be able to

CO1:	Analyze the significance of unit processes and equipment involved in manufacture of organic and inorganic chemical products.
CO2:	Describe the production sequences and manufacturing processes involved in organic chemical process industries
CO3:	Describe the production sequences and manufacturing processes involved in inorganic chemical process industries
CO4:	Ability to construct detailed process flow chart, and develop the associated mass and energy balances using software

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		2									1	2	2	2
CO2	3		2		1	2	2					1	2	2	2
CO3	3		2		1	2	2					1	2	2	2
CO4	3	3			2				3			3	1		

Syllabus

Unit 1

Chemical processing, the role of a chemical engineers in process industries, importance of block diagrams and flow charts, unit operations, unit processes, process utilities and economics, industrial safety and pollution, outline of plant and equipment design, Basics on Flow-sheeting practice using Aspen HYSYS.

Unit 2

Acid and Alkali industry, Fertilizer Industry; Industrial gases; Dyes, Paints & Varnishes; Cement; Glass; Polymer Industry; Pharmaceutical; Paper and Pulp; Sugar; Petroleum Refining & Petrochemicals Industry; Related Green manufacturing process. Industrial production of nanomaterials.

Unit 3

Project in development of Process flow diagram for a given chemical product.

Textbook(s)

1. G.I. Austin, "Shreve's Chemical Process Industries", 5th Edition, Tata McGraw Hill, Singapore, 1990

2. Gopala Rao and M. Sitting, Affiliated East–West Press, 1993.
3. M. B. Hocking, “Handbook of Chemical Technology and Pollution Control”, 3rd Edition, Academic Press, 2005.
4. Aspen Plus®: Chemical Engineering Applications, First Edition. Kamal I.M. Al-Malah.© 2017 John Wiley & Sons, Inc. Published 2017
3. Gil Chaves, I.D., López, J.R.G., García Zapata, J.L., LeguizamónRobayo, A., Rodríguez Niño, G, Process Analysis and Simulation in Chemical Engineering, Springer, 2016

Reference(s)

1. M. Bickford, “Kirk-Othmer - Concise Encyclopedia of Chemical Technology“, (2-volume set), 4th Edition, Wiley-Interscience, 19

23CHE304 NUMERICAL METHODS IN CHEMICAL ENGINEERING L-T-P-C : 3-0-0-3

Pre-Requisite(s) : Calculus, Linear Algebra, Differential Equations, Foundations of data science

Course Objectives

- To impart knowledge on different numerical methods suitable to solve problems relevant to chemical engineering
- To inculcate the ability to apply the apt method for a chemical engineering problem

Course Outcomes

After the completion of this course, student will be able to

CO1:	Develop numerical techniques used for solving linear/non-linear system of equation(s), solving ODE, solving PDE, interpolation and approximation
CO2:	Compare the techniques which can be used for a given type of problem and choose the most suitable method
CO3:	Adapt the apt numerical technique to solve a given chemical engineering problem.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1			1									1	
CO2	1	1			1									1	
CO3	3	2			2								1	2	

Syllabus

Unit 1

Review of Errors: Accuracy and precision, round off error and truncation error; Roots of transcendental and polynomial equations in chemical engineering: bisection method, Iteration methods based on first degree equation, rate of convergence, systems of non-linear equations in chemical engineering. Review of Matrix Algebra: systems of equations, eigen-values and eigenvectors; Solution of system of linear algebraic equations in chemical engineering: Gauss elimination and Gauss Jordan method, Iteration methods, Thomas algorithm for tridiagonal matrices

Unit 2

Interpolation and Approximation in chemical engineering: Lagrange and Newton Interpolation for unequal intervals, finite difference operators, interpolating polynomials using finite differences; Numerical differentiation and integration in chemical engineering; Trapezoidal and Simpson's rules

Unit 3

Review of Ordinary Differential equations (ODEs), Solution of ODEs in chemical engineering: Initial value problem, single-step method, Taylor series method, fourth order Runge Kutta method; Types of boundary

conditions – Dirichlet, Neumann and Mixed/Robin conditions; Finite difference approximations for second order ordinary differential equations.
Solution of Partial Differential Equations (PDEs) in chemical engineering: Elliptic, Parabolic and Hyperbolic

Textbook(s)

1. Steven Chapra and Raymond Canale, Numerical Methods for Engineers, McGraw Hill, 2007
2. Pradeep Ahuja, Introduction to Numerical Methods in Chemical Engineering, PHI Learning Private Limited, 2019
3. Erwin Kreyszig, Advanced Engineering Mathemaics, Wiley, Tenth Edition, 2011

Reference(s)

1. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New age International publishers, Fifth Edition, 2007
2. S. K. Gupta, Numerical Methods for Engineers, New Age International Publishers, 2005
3. Michael Greenberg, Advanced Engineering Mathematics, Prentice Hall, 1998

23CHE381 HEAT TRANSFER LABORATORY L -T-P-C : 0-0-3-1

Pre-Requisites: Process Heat Transfer

Objectives

To gain knowledge by applying theoretical concepts related to heat transfer and analyze different methods to calculate the heat transfer coefficient in various heat transfer problems

Course Outcomes

After the completion of this course, student will be able to

CO1:	Perform the heat conduction experiment through composite slab to find the thermal conductivity.
CO2:	Estimate the heat transfer coefficient for various systems under different convection conditions.
CO3:	Measure the effectiveness of double pipe heat exchanger and economy of single effect evaporator

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3						3	2			3	1	3
CO2	3	3	3						3	2			3	1	3
CO3	3	3	3						3	2			3	1	3

List of Experiments

Estimation of thermal conductivity

Heat transfer coefficient in natural and forced convection

Heat transfer with combination of two or more modes of heat transfer viz. conduction, convection, and radiation

Overall Heat transfer coefficient and effectiveness– double pipe heat exchanger, shell and tube heat exchanger, jacketed vessel

Estimation of fin efficiency

Overall heat transfer coefficient and efficiency in Evaporators

Heat transfer coefficient in Condensation and boiling

Textbooks(s)

1. Kern, D.Q., Process Heat Transfer, International Student Edition, McGraw Hill (2002).
2. Yunus A. Cengel, "Heat Transfer a Practical Approach", Tata McGraw-Hill Education, 4th Edition,2012.

Reference(s)

1. Binay K Datta, Heat Transfer – Principles and Applications, PHI Learning Pvt Ltd, 2001.
2. McCabe, Simth, and Harriott, Unit Operations in Chemical Engineering, 6th Edition, McGraw Hill, International Edition, 2001.

3. J. M Coulson and J. F. Richardson, Chemical Engineering Vol. I, 4th Edition, Asian Books Pvt Ltd,India, 1998.

23CHE382 COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING LABORATORY L-T-P-C : 0-0-3-1

Pre-Requisites : Calculus, Linear Algebra, Differential Equations, Foundations of data science

Course Objectives

This course is designed to train students in:

- Solving chemical engineering problems using numerical methods
- Gain proficiency in scientific computing tools such as MATLAB®
- Write simple programs in scientific computing tools such as MATLAB® to solve chemical engineering problems.

Course Outcomes

After the completion of this course, student will be able to

CO1	Demonstrate ability to use scientific computing tools (e.g., MATLAB®) to graph functions, write simple programs, perform calculations.
CO2	Use scientific computing tools (e.g., MATLAB®) to solve systems of linear algebraic equations, interpolate function values and perform linear regression involving chemical engineering applications.
CO3	Use scientific computing tools (e.g., MATLAB®) to solve single and systems of nonlinear algebraic equations involving chemical engineering applications.
CO4	Use scientific computing tools (e.g., MATLAB®) to solve single first & second order and systems of first order ordinary differential equations involving chemical engineering applications.
CO5	Use scientific computing tools (e.g., MATLAB®) to solve simple partial differential equations involving chemical engineering applications.
CO6	Exhibit ethical principles in engineering profession by practicing ethical approaches in computations, collection and reporting of data and adhering to the report formats set by the instructor.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1			2		3				3	2		1		3	
CO2	3	3	3	1	3				3	2		1	2	3	
CO3	3	3	3	1	3				3	2		1	2	3	
CO4	3	3	3	1	3				3	2		1	2	3	
CO5	3	3	3	1	3				3	2		1	2	3	
CO6								3				1			

Syllabus:

The laboratory course will involve nine exercises listed below. An indicative list of chemical engineering applications is presented for each exercise. Selected applications will be taught.

1. Introduction to MATLAB®, Programming in MATLAB®, Basic Exercises
2. Systems of Linear Algebraic Equations: Material & Energy Balances, Simple Flowsheets, Band Diagonal Matrices
3. Interpolation and Linear Regression: Correlations for Thermodynamic and Transport Properties, Correlations in Fluid, Heat and Mass Transfer (e.g., Nusselt Number, Sherwood Number), Kinetics
4. Single Nonlinear Algebraic Equations: Thermodynamics, Flash, Kinetics
5. Systems of Nonlinear Algebraic Equations: Simple Problems, Multicomponent Equilibria, Multiple Reactions in a Reactor
6. First Order Ordinary Differential Equations: Euler and 4th Order RK Methods – Heat Exchanger, Stirred Tank Heaters, Pneumatic Conveying, CSTR, PFR, Recycle
7. System of First Order Ordinary Differential Equations: Double Pipe Heat Exchanger, Series of Stirred Tank Heaters, CSTRs/PFRs in Series/Parallel, Series/Parallel Reactions in Batch/CSTR/PFR Reactors
8. Second Order Ordinary Differential Equations: Finite Difference, Heat Transfer from Fins, Reaction-Diffusion in Pores, Convective-Diffusion-Reaction Equations
9. Partial Differential Equations: Conversion into Systems of Linear/Nonlinear Algebraic Equations, Heat Equation, Shockwave, Laplace Equation

Textbook(s):

1. Pradeep Ahuja, *Introduction to Numerical Methods in Chemical Engineering*, Prentice Hall India, 2010.
2. Jaan Kiusalaas, *Numerical Methods in Engineering with MATLAB®*, Cambridge University Press, 2005.
3. Kenneth Beers, *Numerical Methods for Chemical Engineering: Applications in MATLAB®*, 2007.

Reference(s)

1. Alkis Constantinides and Navid Moustofi, *Numerical Methods for Chemical Engineers with MATLAB® Applications*, Prentice Hall, 1999.

23LSE301	Life Skills for Engineers III	L-T-P-C: 1-0-2-2

Pre-requisite: Willingness to learn, communication skills, basic English language skills, knowledge of high school level mathematics.

Course Objectives

- Help students understand corporate culture, develop leadership qualities and become good team players
- Assist them in improving group discussion skills
- Help students to sharpen their problem solving and reasoning skills
- Empower students to communicate effectively

Course Outcomes

CO1 - Soft Skills: To improve the inter-personal communication and leadership skills, vital for arriving at win-win situations in Group Discussions and other team activities.
CO2 - Soft Skills: To develop the ability to create better impact in a Group Discussions through examination, participation, perspective-sharing, ideation, listening, brainstorming and consensus.
CO3 - Aptitude: To identify, investigate and arrive at appropriate strategies to solve questions on geometry, statistics, probability and combinatorics.
CO4 - Aptitude: To analyze, understand and apply suitable methods to solve questions on logical reasoning.
CO5 - Verbal: To be able to use diction that is more refined and appropriate and to be competent in spotting grammatical errors and correcting them.
CO6-Verbal: To be able to logically connect words, phrases, sentences and thereby communicate their perspectives/ideas convincingly.

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									3	3	2	3
CO2										3	2	2
CO3		3		2								
CO4		3		2								
CO5										3		3
CO6									3	3		3

Syllabus

Soft Skills

Professional Grooming and Practices: Basics of corporate culture, key pillars of business etiquette – online and offline: socially acceptable ways of behavior, body language, personal hygiene, professional attire and Cultural adaptability and managing diversity. Handling pressure, multi-tasking. Being enterprising. Adapting to corporate life: Emotional Management (EQ), Adversity Management, Health consciousness. People skills, Critical Thinking and Problem solving.
Group Discussions: Advantages of group discussions, Types of group discussion and Roles played in a group discussion. Personality traits evaluated in a group discussion. Initiation techniques and maintaining the flow of the discussion, how to perform well in a group discussion. Summarization/conclusion.

Aptitude

Problem Solving III
Geometry: 2D, 3D, Coordinate Geometry, and Heights & Distance.

Permutations & Combinations: Basics, Fundamental Counting Principle, Circular Arrangements, and Derangements.
Probability: Basics, Addition & Multiplication Theorems, Conditional Probability and Bayes' Theorem.
Statistics: Mean, Median, Mode, Range, Variance, Quartile Deviation and Standard Deviation.
Logical Reasoning: Blood Relations, Direction Test, Syllogisms, Series, Odd man out, Coding \& Decoding, Cryptarithmetic Problems and Input - Output Reasoning.

Verbal

Vocabulary: Create an awareness of using refined language through idioms and phrasal verbs.
Grammar (**Upper Intermediate-Advanced**): Train Students to comprehend the nuances of Grammar and empower them to spot errors in sentences and correct them.
Reasoning: Enable students to connect words, phrases and sentences logically.
Oral Communication Skills: Aid students in using the gift of the gab to interpret images, do a video synthesis, try a song interpretation or elaborate on a literary quote.
Writing Skills: Practice closet tests that assess basic knowledge and skills in usage and mechanics of writing such as punctuation, basic grammar and usage, sentence structure and rhetorical skills such as writing strategy, organization, and style.

References:

1. Students" Career Planning Guide, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
2. Soft Skill Handbook, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
3. Adair. J., (1986), *"Effective Team Building: How to make * winning team"*, London, U.K
4. Gulati. S., (1006) "Corporate Soft Skills", New Delhi, India: Rupa & **Co.**
5. The hard truth about Soft Skills, by Amazon Publication.
6. Verbal Skills Activity Book, CIR, AVVP
7. English Grammar & Composition, Wren & Martin
8. Public Sector – Engineer Management Trainee Recruitment Exam (General English)
9. Nova's GRE Prep Course, Jeff Kolby, Scott Thornburg & Kathleen Pierce
10. Student Workbook: Quantitative Aptitude & Reasoning, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
11. Quantitative Aptitude for All Competitive Examinations, Abhijit Guha.
12. How to Prepare for Quantitative Aptitude for the CAT, Arun Sharma.
13. How to Prepare for Data Interpretation for the CAT, Arun Sharma.
14. How to Prepare for Logical Reasoning for the CAT, Arun Sharma.
15. Quantitative Aptitude for Competitive Examinations, R S Aggarwal.
16. A Modern Approach to Logical Reasoning, R S Aggarwal.
17. A Modern Approach to Verbal & Non-Verbal Reasoning, R S Aggarwal.

Evaluation Pattern

Assessment	Internal	External
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25
Continuous Assessment (CA)* – Verbal	10	25
Total	50	50

*CA - Can be **presentations, speaking activities and tests.**

23ENV300 ENVIRONMENTAL SCIENCE L-T-P-C: P/F

Course Objectives:

- To study the nature and facts about environment
- To appreciate the importance of environment by assessing its impact on the human world
- To study the integrated themes and biodiversity, pollution control and waste management

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Explain aspects of nature and environment
CO2:	Analyse impact of environment on human world
CO3:	Comprehend pollution control and waste management

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO01						3	2	3							
CO02						3	2	3							
CO03						3	2	3							

Syllabus

Unit 1

Over view of the global environment crisis – Biogeochemical cycles – Climate change and related international conventions and treaties and regulations – Ozone hole and related International conventions and treaties and regulations – Overpopulation – energy crisis – Water crisis – ground water hydrogeology – surface water resource development.

Unit 2

Ecology, biodiversity loss and related international conventions – treaties and regulations – Deforestation and land degradation – food crisis – water pollution and related International and local conventions – treaties and regulations – Sewage domestic and industrial and effluent treatment – air pollution and related international and local conventions – treaties and regulations – Other pollution (land, thermal, noise).

Unit 3

Solid waste management (municipal, medical, e-waste, nuclear, household hazardous wastes) – environmental management – environmental accounting – green business – eco-labelling – environmental impact assessment – Constitutional – legal and regulatory provisions – sustainable development.

Text Book(s)

1. *R. Rajagopalan,“Environmental Studies – From Crisis to Cure”, Oxford University Press, 2005, ISBN 0-19-567393-X.*

Reference(s)

2. *G.T.Miller Jr., "Environmental Science", 11th Edition, Cenage Learning Pvt. Ltd., 2008.*
3. *Benny Joseph, "Environmental Studies", Tata McGraw-Hill Publishing company Limited, 2008.*

23LIV390 LIVE-IN-LAB I L-T-P-C: 0-0-0-3

Course Objectives

- Identify and analyse the various challenge indicators present in the village by applying concepts of Human Centered Design and Participatory Rural Appraisal.
- User Need Assessment through Quantitative and Qualitative Measurements
- Designing a solution by integrating Human Centered Design concepts
- Devising proposed intervention strategies for Sustainable Social Change Management

Course Outcome

CO1: Learn ethnographic research and utilise the methodologies to enhance participatory engagement.
CO2: Prioritize challenges and derive constraints using Participatory Rural Appraisal.
CO3: Identify and formulate the research challenges in rural communities.
CO4: Design solutions using human centered approach.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO01		3		3		1	1	3	3	3		3			
CO02		3						3	3	3					
CO03		3					1	3	3	3		3			
CO04	3		3				3	3	3	3		3			

Syllabus

This initiative is to provide opportunities for students to get involved in coming up with technology solutions for societal problems. The students shall visit villages or rural sites during the vacations (after 4th semester) and if they identify a worthwhile project, they shall register for a 3-credit Live-in-Lab project, in the fifth semester.
Thematic Areas
• Agriculture & Risk Management
• Education & Gender Equality
• Energy & Environment
• Livelihood & Skill Development
• Water & Sanitation
• Health & Hygiene
• Waste Management & Infrastructure
The objectives and the projected outcome of the project will be reviewed and approved by the department chairperson and a faculty assigned as the project guide.

Evaluation Pattern

Assessment	Marks
Internal (Continuous Evaluation) [75 marks]	
Workshop (Group Participation)	15
Village Visit Assignments & Reports	15
Problem Identification and Assessment	15
Ideation: Defining the Needs, Proposed Designs & Review	20
Poster Presentation	10
External [25 marks]	
Research Paper Submission	25
Total	100

SEMESTER 6

23CHE311 MASS TRANSFER OPERATIONS - II L -T-P-C : 3-0-0-3

Pre-Requisites: Chemical Process Calculations, Fluid and Particle Mechanics, Chemical Engineering Thermodynamics, Process Heat Transfer, Mass Transfer Operations - I

Course Objectives

The objective of the course is provide understanding of different separation techniques such as distillation, adsorption, liquid-liquid extraction, solid liquid extraction etc.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Design distillation column using McCabe-Thiele and Ponchon-Savarit methods.
CO2:	Devise calculations for crystallizers and continuous extractors
CO3:	Validate calculations to design adsorption columns, leaching units, and miscellaneous equipment.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2										3		
CO2	3	2	2										3	2	
CO3	3	3	2										3	2	

Syllabus

Unit 1

Design of mass transfer equipment based on the concept of the equilibrium stage. Distillation: vapor-liquid equilibria, Raoult's law and deviations from ideality, methods of distillation; Equilibrium and operating line concepts; Design calculations by McCabe-Thiele and Ponchon-Savarit methods; Continuous contact distillation (packed tower) design; Extractive and azeotropic distillation, low pressure distillation; Steam distillation; Tray tower equipment.

Design of mass transfer equipment based on the concept of the equilibrium stage;

Unit 2

Crystallization: Equilibrium, theories of crystallization, purity, yield, energy requirements, the kinetics of crystallization – nucleation and growth; population balance model, MSMPR crystallizer, crystallization equipment, and Membrane-based Crystallizers

Liquid-liquid extraction: Equilibrium in ternary systems; Design calculations for batch and continuous extractors, equipment – spray, packed and mechanically agitated contactors; Pulsed extractors, centrifugal extractors.

Unit 3

Leaching: Solid-liquid equilibria; Equipment – batch and continuous types; Calculation of number of stages.
Adsorption and Ion exchange: Theories of adsorption of gases and liquids; Principle of ion exchange; Equipment for batch and continuous operation; Design calculations for adsorption and for ion exchange resins.
Miscellaneous separation processes: Introduction to membrane separation process; Solid and liquid membranes; Reverse osmosis; Electrodialysis.

Textbook(s)

1. R.E. Treybal, Mass Transfer Operations, 3rd Edition, McGraw Hill, 1981.
2. J.D. Seader and E. J. Henley, Separation Process Principles, 2nd Edition, Wiley, 2005.

Reference(s)

1. J.M.Coulson and J.F. Richardson, "Chemical Engineering Vol. II", 4th Edition, Asian Books Pvt. Ltd, India, 1998.
2. W.L.McCabe, J.C.Smith and P. Harriot, "Unit operations of Chemical Engineering", 6th Edition, McGraw Hill, International Edition, 2001.

23CHE312 PROCESS DYNAMICS AND CONTROL L -T-P-C : 3-1-0-4

Pre-Requisite(s): Differential Equations

Course Objectives

The objective of the course is to understand dynamic modeling of a physical process using first principles, develop transfer functions, understand the principle of various control configuration, analyze control system stability and apply the control system in various processes.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Develop response of a system for various input functions from the system transfer function derived from first principles.
CO2:	Develop block diagram to analyze transient response of control schemes for various controller configurations for a given process
CO3:	Analyze the stability of a system for different modes of control using different stability criteria to perform tuning of process controllers
CO4:	Explain different advanced control strategies and control valve characteristics.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	-	-	-	-	-	-	-	-	3	3	1
CO2	3	3	3	3	-	-	-	-	-	-	-	-	3	3	3
CO3	3	3	3	3	2	-	-	-	-	-	-	-	3	3	3
CO4	3	3	3	2	-	-	-	-	-	-	-	-	3	3	1

Syllabus

Unit 1

Review of Laplace transformation. Open – Loop systems, Transfer functions and input output models, Dynamic behavior of first order systems in response to various forcing functions, Self- regulating and non-self regulating first order systems, Transfer function and dynamic response of first order systems in series, systems with dead time and second order systems. Linearization and its application in process control.

Unit 2

Closed loop control systems: concept of feedback control, development of block diagram for feedback control systems, servo and regulatory problems, transfer function for controllers and final control element, Control Valve Characteristics. Closed loop transfer function and block diagram reduction, transient response of closed – loop control systems – effect of proportional, integral, derivative and composite control action. Stability Analysis of Feedback systems: Characteristic equation, Concept of poles and zeros of a transfer function, The role of poles and zeros on the dynamics of a system, Routh – Hurwitz stability criterion, root locus analysis.

Unit 3

Frequency response of open and closed – loop systems, Bode plots, The concept of gain and phase margins, Bode stability criterion, Ziegler-Nicholas tuning rules for controller system design, Cohen-Coon settings for controller design. Introduction to advanced control systems - cascade control, Feed-forward control, ratio control. Deadtime compensation; Control of chemical processes. Introduction to computer control of chemical processes and Decentralized control based on IoT.

(Software like MATLAB can be used for simulating dynamic systems and stability analysis)

Textbook(s)

1. Donald R. Coughanowr, Steven E. LeBlanc, "Process Systems Analysis and Control – 3rdEdn., Tata Mcgraw Hill Education, 2011.
2. G. Stephanopoulos, "Chemical Process Control", 8thEdn, Prentice Hall of India. 2015.

Reference(s)

1. Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp, Francis J. Doyle III, Process Dynamics and Control, 3rd Edition, Wiley India Pvt. Ltd., New Delhi, 2013
2. Peter Harriott, Process Control, Tata McGraw Hill, New Delhi, 2009

23CHE313	ENVIRONMENTAL ENGINEERING AND SUSTAINABILITY IN PROCESS INDUSTRIES	L -T-P-C : 3-0-0-3

Pre-Requisite(s): None

Course Objectives

To enable students to have a career in the public or private sector to manage the complexities of real-life environmental engineering problems with an understanding of the principles of wastewater treatment processes. The course also deals with insights into air pollution modeling, emission testing, hazardous waste management, and zero discharge.

Course Outcomes

After the completion of this course, student will be able to

CO1:	Interpret basic understanding of wastewater standards, pollutants, and water quality testing.
CO2:	Design systems, processes, and equipment for control and remediation of wastewater pollution in chemical process industries
CO3:	Gain proficiency with fundamental concepts related to air pollution modeling, emission testing, and controls.
CO4:	Assess the deployment of appropriate industrial and hazardous waste management facilities in chemical plants.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
COO1	3	3	2			1	1				1		2	1	2
COO2	3	3	2			1	1				1		2	1	1
COO3	3	3	2			1	1				1		2	1	1
COO4	3	3	2			1	1				1		2	1	1

Syllabus

Unit 1

Wastewater Pollution Control: wastewater characteristics: physical, chemical and bacteriological, Types of pollutants in wastewater of chemical industries, Methods of sampling, preservation of samples and analysis. Methods for the treatment of liquid wastes: Physical, chemical and biological methods, Selection and design of equipment. Physical treatment: pre-treatment, solids removal by setting and sedimentation, filtration centrifugation, coagulation and flocculation. Chemical Treatment: Anaerobic with special reference to UASB and aerobic treatment biochemical kinetics, trickling filter, activated sludge process, lagoons, aeration systems, fluidized bed bioreactors; Disinfection, Ion exchange, Electro-dialysis, Reverse Osmosis.

Pollution Prevention : Implications of environmental constraints for process design, Concept of common effluent treatment; Environmental legislations, Role of Government and Industries Pollution control in selected process industries– fertilizer industries, petroleum refineries and petrochemical units, pulp and paper industries, Tanning industries, Sugar industries, Dairy, Alcohol industries, Electroplating and metal finishing industries, Radioactive wastes, ranking of wastewater treatment alternatives, Case Studies

Unit 2

Air Pollution Control: Sources and effects of air pollutants Methods of measuring and sampling of gaseous and particulate pollutants, meteorological aspects of air pollution temperature lapse rate and stability – Adiabatic lapse rate - Wind Rose - Inversion – Wind velocity and turbulence - Plume behavior - Dispersion of air pollutants- Air Quality Modeling. Selection and Design of particulate and gaseous pollution control equipment; mechanical separation, Bag filter, cyclone separator, electrostatic precipitation, wet gas scrubbing, adsorption, and absorption.

Unit 3

Cleaner production: Waste Management Approach – Waste Audit –land fills; value extraction from the wastes; Industrial waste management and Pollution Prevention: Process modification, alternative raw material, recovery of by co-product, recycle and reuse of waste, energy recovery and waste utilization. Reduction – Material and process modifications – Recycle, reuse and byproduct recovery – Applications. Wastes Management: Characterization of wastes-hazardous and non-hazardous wastes. Hazardous wastes - Physico chemical treatment – solidification – incineration – Secured landfills.

Textbook(s)

1. C.S. Rao, "Environmental Pollution Control Engineering," 2nd Edition, New Age International Publishers, 2006.
2. G. Kiely, "Environmental Engineering", Special Indian Edition, Tata McGraw-Hill, 2009.
3. G. Tchobanoglous, F.L. Burton, and H.D. Stensel, "Wastewater Engineering: Treatment and Reuse", 4th Edition, McGraw Hill Science, 2002.
4. S.P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill, 2001.
5. A.P. Sincero and G.A. Sincero, "Environmental Engineering: A Design Approach", Prentice Hall, 1995.

23CHE391 SEMINAR L -T-P-C : 0-0-3-1

Pre-Requisite(s) : None

Course Objectives

The course 'Seminar' is intended to enable a B.Tech. graduate to read, understand, present and prepare report about an academic document. The learner shall search in the literature including peer reviewed journals, conference, books, project reports etc., and identify an appropriate paper/thesis/report in her/his area of interest, in consultation with her/his seminar guide. This course can help the learner to experience how a presentation can be made about a selected academic document and also empower her/him to prepare a technical report.

Course Outcomes

After the completion of the course the student will be able to

CO1:	Identify academic documents from the literature which are related to her/his areas of Interest.
CO2:	Read and apprehend an academic document from the literature which is related to her/ his areas of interest.
CO3:	Prepare a presentation about an academic document.
CO4:	Give a presentation about an academic document.
CO5:	Prepare a technical report

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1		2	1					3	1	2	3
CO2	3	3	2	3		2	1					3	1	2	3
CO3	3	2			3			1		2		3	1	2	3
CO4	3				2			1		3		3	1	2	3
CO5	3	3	3	3	2			2		3		3	1	2	3

General Guidelines

- The Department shall form an Internal Evaluation Committee (IEC) for the seminar with academic coordinator for that program as the Chairperson/Chairman and seminar coordinator & seminar guide as members. During the seminar presentation of a student, all members of IEC shall be present.
- Formation of IEC and guide allotment shall be completed within a week after the end semester examination (or last working day) of the previous semester.
- Guide shall provide required input to their students regarding the selection of topic/paper.
- Choosing a seminar topic: The topic for a UG seminar should be current and broad based rather than a very specific research work. It's advisable to choose a topic for the seminar to be closely linked to the final year project area. Every member of the project team could choose or be assigned seminar topics that covers various aspects linked to the Project area.

- A topic/paper relevant to the discipline shall be selected by the student during the semester break.
- Topic/Paper shall be finalized in the first week of the semester and shall be submitted to the IEC.
- The IEC shall approve the selected topic/paper by the second week of the semester.
- Accurate references from genuine peer reviewed published material to be given in the report and to be verified.

Evaluation Pattern:

Assessment Title	Continuous Assessment
Background knowledge and Relevance of topic	20
Seminar Diary	20
Presentation	40
Report	20
Total	100

Total marks: 100, only CIE, minimum required to pass 50

23CHE383 MASS TRANSFER LABORATORY L -T-P-C : 0-0-3-1

Pre-Requisite(s): Mass Transfer Operations - I

Course Objectives

This lab familiarizes the student with various mass transfer operations by doing experiments. This lab helps the students to operate and understand the working of mass transfer equipment.

Course Outcomes:

After the completion of the lab the student will be able to

CO1:	Apply the fundamental knowledge of mass transfer in related practical problems.
CO2:	Experiment with various mass transfer equipment and present the experimental data meaningfully by preparing cogent reports.
CO3:	Use modern computing tools necessary for analysis of the experimental data in the laboratory.
CO4:	Exhibit ethical principles in engineering profession by practicing ethical approaches in experimental investigation, collection and reporting of data and adhering to the safety ethics set by the laboratory.
C**O5:**	Practice work in diverse groups and perform laboratory experiments.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3											1	3		
CO2	3							1		3		2	2	1	3
CO3					3							1		3	2
CO4						3		2					1		
CO5									3				1		

LIST OF EXPERIMENTS (A minimum of 8 experiments has to be conducted)

1. Diffusion coefficient measurement
2. Simple Distillation
3. Steam Distillation
4. Surface Evaporation-free convection mass transfer
5. Liquid extraction- Determination of Ternary liquid-liquid equilibria
6. Simple leaching-varying solvent to feed ratio
7. Simple leaching- varying number of stages
8. Cross current leaching
9. Counter current leaching
10. Adsorption Isotherm
11. Atmospheric batch drying
12. Wetted wall column-measurement of mass transfer coefficient
13. Continuous and staged equipment for mass transfer

14. Vapor-Liquid Equilibrium of a Binary Mixture
15. Extraction in packed and plate columns
16. Distillation in packed columns
17. Characteristics and Efficiency of mass transfer equipment

Reference(s)

1. Robert E Treybal, Mass Transfer Operations, McGraw Hill.
2. Y. V. C. Rao, Chemical Engineering Thermodynamics, University Press, 2001
3. J. M Coulson and J. F. Richardson, Chemical Engineering Vol. II, 4 th Edition, Asian Books Pvt Ltd, India, 1998.
4. McCabe, Simth, and Harriot, Unit Operations in Chemical Engineering, 6 th Edition, McGraw Hill, International Edition, 2001.
5. K V Narayanan and B Lakshmikutty, Mass Transfer: Theory and Applications, CBS Publishers and Distributors Pvt. Ltd.

23CHE384 CHEMICAL REACTION ENGINEERING AND THERMODYNAMICS LABORATORY L-T-P-C: 0-0-3-1

Pre-requisites: Chemical Engineering Thermodynamics, Chemical Reaction Engineering

Course Objectives

This course provides hands-on practical training on understanding, operating, measuring, analysing and characterizing chemical engineering units and phenomena, with specific focus on thermodynamics and chemical reaction engineering. Thermodynamics lab aims to introduce students to thermodynamic analysis of machines (e.g., turbine, refrigerator) and on analysis of equilibria of mixtures (e.g., VLE, LLE, reaction). Chemical Reaction Engineering Lab introduces obtaining data from different reactors and use the experimental data to estimate the rate parameters of a reaction.

Course Outcomes

At the end of the course student would be able to:

CO1:	Calculate the efficiency of a refrigeration cycle and dryness fraction in a two-phase systems using thermodynamic laws
CO2:	Calculate the enthalpy of vaporization of a liquid and heat of solution for a solid substance using Clasius-Clapeyron equation and energy balances
CO3:	Estimate the rate parameters (rate constant, order, pre-exponential factor and activation energy from experimental data obtained from batch, mixed flow and plug flow reactors
CO4:	Determine the mixing conditions in a given reaction vessel using either tanks-in-series model or dispersion model from tracer experimental data

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	2				3	2		1	2	1	3
CO2	3	3	3	3	2				3	2		1	2	1	3
CO3	3	2	3	2	3								3	2	
CO4	3	2	3	2	3	2							3	2	

Syllabus

Thermodynamics Experiments

1. Thermodynamic Analysis of a Refrigerator
2. Vapor-Liquid Equilibrium of a Binary Mixture
3. Liquid-Liquid Equilibrium apparatus
4. Heat of solution of a salt such as ammonium chloride

Chemical Reaction Engineering Experiments

1. Batch reactor

2. Semi-batch reactor
3. Plug flow reactor (PFR)
4. Continuous stirred tank reactor (CSTR)
5. Reactor combinations – PFR+CSTR or CSTRs
6. RTD studies to find the mixing phenomena in the reactors

Textbook(s)

1. Y. V. C. Rao, Chemical Engineering Thermodynamics, University Press, 2001
2. Y. Cengel, M. A. Boles, Thermodynamics: An Engineering Approach, McGraw Hill Education, 8th Edition, 2017
3. Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, John-Wiley Publishers, 1999

Reference(s)

1. H.S. Fogler, Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall India, 2000

Pre-requisite: Self-confidence, presentation skills, listening skills, basic English language skills, knowledge of high school level mathematics.

23LSE311	Life Skills for Engineers IV	L-T-P-C: 1-0-2-2

Course Objectives

- Help students prepare resumes and face interviews with confidence
- Support them in developing their problem-solving ability
- Assist them in improving their problem solving and reasoning skills
- Enable them to communicate confidently before an audience

Course Outcomes

CO1 - Soft Skills: To acquire the ability to present themselves confidently and showcase their knowledge, skills, abilities, interests, practical exposure, strengths and achievements to potential recruiters through a resume, video resume, and personal interview.
CO2 - Soft Skills: To have better ability to prepare for facing interviews, analyse interview questions, articulate correct responses and respond appropriately to convince the interviewer of one's right candidature through displaying etiquette, positive attitude and courteous communication.
CO3 - Aptitude: To manage time while applying suitable methods to solve questions on arithmetic, algebra and statistics.
CO4 - Aptitude: To investigate, understand and use appropriate techniques to solve questions on logical reasoning and data analysis.
CO5 - Verbal: To use diction that is less verbose and more precise and to use prior knowledge of grammar to correct/improve sentences.
CO6 -Verbal: To understand arguments, analyze arguments and use inductive/deductive reasoning to arrive at conclusions. To be able to generate ideas, structure them logically and express them in a style that is comprehensible to the audience/recipient.

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									3	3		2
CO2								2	3	3		2
CO3		3		2								
CO4		3		2								
CO5										3		3
CO6									3	3		3

Syllabus

Soft Skills

Team Work: Value of teamwork in organizations, Definition of a team. Why team? Effective team building. Parameters for a good team, roles, empowerment and need for transparent communication, Factors affecting team effectiveness, Personal characteristics of members and its influence on team. Project Management Skills, Collaboration skills.
Leadership: Initiating and managing change, Internal problem solving, Evaluation and co-ordination, Growth and productivity, Importance of Professional Networking.
Facing an interview: Importance of verbal & aptitude competencies, strong foundation in core competencies, industry orientation / knowledge about the organization, resume writing (including cover letter, digital profile and video resume),

being professional. Importance of good communication skills, etiquette to be maintained during an interview, appropriate grooming and mannerism.

Aptitude

Problem Solving II
Sequence and Series: Basics, AP, GP, HP, and Special Series.
Data Sufficiency: Introduction, 5 Options Data Sufficiency and 4 Options Data Sufficiency.
Logical reasoning: Clocks, Calendars, Cubes, Non-Verbal reasoning and Symbol based reasoning.
Campus recruitment papers: Discussion of previous year question papers of all major recruiters of Amrita Vishwa Vidyapeetham.
Competitive examination papers: Discussion of previous year question papers of CAT, GRE, GMAT, and other management entrance examinations.
Miscellaneous: Interview Puzzles, Calculation Techniques and Time Management Strategies.

Verbal

Vocabulary: Empower students to communicate effectively through one-word substitution.
Grammar: Enable students to improve sentences through a clear understanding of the rules of grammar.
Reasoning: Facilitate the student to tap his reasoning skills through Syllogisms, critical reasoning arguments and logical ordering of sentences.
Reading Comprehension (**Advanced**): Enlighten students on the different strategies involved in tackling reading comprehension questions.
Public Speaking Skills: Empower students to overcome glossophobia and speak effectively and confidently before an audience.
Writing Skills: Practice formal written communication through writing emails especially composing job application emails.

References:

1. Students" Career Planning Guide, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
2. Soft Skill Handbook, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
3. Adair. J., (1986), "Effective Team Building: How to make * winning team", London, U.K
4. Gulati. S., (1006) "Corporate Soft Skills", New Delhi, India: Rupa & Co.
5. The hard truth about Soft Skills, by Amazon Publication.
6. Verbal Skills Activity Book, CIR, AVVP
7. English Grammar & Composition, Wren & Martin
8. Public Sector – Engineer Management Trainee Recruitment Exam (General English)
9. Nova's GRE Prep Course, Jeff Kolby, Scott Thornburg & Kathleen Pierce
10. A Modern Approach to Verbal Reasoning – R.S. Aggarwal
11. Student Workbook: Quantitative Aptitude & Reasoning, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
12. Quantitative Aptitude for All Competitive Examinations, Abhijit Guha.
13. How to Prepare for Quantitative Aptitude for the CAT, Arun Sharma.
14. How to Prepare for Data Interpretation for the CAT, Arun Sharma.
15. How to Prepare for Logical Reasoning for the CAT, Arun Sharma.
16. Quantitative Aptitude for Competitive Examinations, R S Aggarwal.
17. A Modern Approach to Logical Reasoning, R S Aggarwal.
18. A Modern Approach to Verbal & Non-Verbal Reasoning, R S Aggarwal

Evaluation Pattern

Assessment	Internal	External
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25

Continuous Assessment (CA)* – Verbal	10	25
Total	50	50

*CA - Can be **presentations, speaking activities and tests.**

23LIV490 LIVE-IN-LAB II L-T-P-C: 0-0-0-3

Course Objectives

- Proposal writing in order to bring in a detailed project planning, enlist the materials required and propose budget requirement.
- Use the concept of CoDesign to ensure User Participation in the Design Process in order to rightly capture user needs/requirements.
- Building and testing a prototype to ensure that the final design implementation is satisfies the user needs, feasible, affordable, sustainable and efficient.
- Real time project implementation in the village followed by awareness generation and skill training of the users (villagers)

Course Outcome

CO1: Learn co-design methodologies and engage participatorily to finalise a solution
CO2: Understand sustainable social change models and identify change agents in a community
CO3: Learn Project Management to effectively manage the resources
CO4: Lab scale implementation and validation.
CO4: Prototype implementation of the solution

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO01	1	1	3	3			1	3	3	3		3			
CO02									3	3					
CO03									3	3	3				
CO04	3		3			3	1	3	3	3		3			
C)5			1						3	3					

Syllabus

The students shall visit villages or rural sites during the vacations (after 6th semester) and if they identify a worthwhile project, they shall register for a 3-credit Live-in-Lab project, in the fifth semester.

Thematic Areas

- Agriculture & Risk Management
- Education & Gender Equality
- Energy & Environment
- Livelihood & Skill Development
- Water & Sanitation
- Health & Hygiene
- Waste Management & Infrastructure

The objectives and the projected outcome of the project will be reviewed and approved by the department chairperson and a faculty assigned as the project guide.

Evaluation Pattern

Assessment	Marks
Internal (Continuous Evaluation) [63 marks]	
1. Proposed Implementation	2
1. Proposed Implementation	**2**
Presentation Round	
2. Proposal Submission + Review	**6**
3. Co-design	**6**
i. Village Visit I (Co-Design Field Work Assignments)	4
ii. Presentation of Co-design Assessment	2
4. Prototype Design	**14**
i. Prototype Design	4
ii. Prototype Submission	8
iii. Sustenance Plan	2
5. Implementation	**35**
i. Implementation Plan Review	3
ii. Implementation	24
iii. Testing & Evaluation	4
External [37 marks]	
6. Research Paper	**18**
7. Final Report	**15**
8. Poster Presentation	**4**
Total	**100**

SEMESTER 7

23CHE401 TRANSPORT PHENOMENA L-T-P-C: 3-0-0-3

Pre-Requisite: Chemical process Calculations, Energy balance and Thermodynamics, Fluid and Particle Mechanics, Process Heat Transfer, Mass Transfer Operations I, Mass Transfer Operations II , Chemical reaction Engineering

Course Objectives

- To impart the knowledge in transport of momentum, heat and mass transport and provide insight into the dependence of temperature and pressure on the transport coefficients.
- To derive simple shell balances to formulate basic conservation equations of transport processes for solving selected engineering problems which can be solved analytically.
- To give basic axioms of conservations namely conservation of momentum, energy and mass

Course Outcomes

At the end of the course students would be able to:

CO1:	Describe the mechanisms of various transport processes using principles of conservation of mass, momentum, and energy, and explain the origin of transport properties
CO2:	Derive models and develop solutions for velocity profiles and flow rates in systems involving momentum transport and boundary layer
CO3:	Derive models and develop solutions for temperature profiles and heat fluxes in systems involving energy transport through various mechanisms
CO4:	Derive models and develop solutions for concentration profiles and species fluxes in systems involving species transport in binary and multicomponent mixtures

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

CO Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	2	2					2				3	2	
CO2	3	2	2	2					2				3	3	
CO3	3	3	2	2					2				3	3	
CO4	3	3	3	3					2				3	3	

Syllabus

Unit 1

Review of basic vector algebra and introduction to tensors, Macroscopic – Microscopic-Molecular views of phenomena; Momentum Transport: viscosity, pressure and temperature effect on viscosity of gases and liquids, Newton's law of viscosity, mechanisms of momentum transport, non-Newtonian fluids & power-law models, derivation of velocity profile using shell balance method, velocity distributions in falling film and circular tube;

equations of continuity, motion, and mechanical energy; use of equations of change to solve flow problems; unsteady viscous flow.

Unit 2

Energy Transport: Thermal conductivity, temperature and pressure effect on thermal conductivity of gases and liquids, Fourier's law, mechanisms of energy transport, derivation of temperature profile using shell energy balance (with electrical, nuclear, viscous and chemical heat source); temperature distribution in solids and laminar flow, heat conduction through composite walls, and cylinders; Combined energy flux vector; equation of energy (alternate forms) - applications to specific systems (forced convection laminar flow in tube, tangential flow in annulus, transpiration cooling); unsteady heat conduction in solids.

Unit 3

Mass Transport: Diffusivity, mechanisms of mass transport, concentration distribution in solids and in laminar flow, Fick's law, temperature and pressure effect, theory of diffusion in gases and liquids, types of diffusion (ordinary, thermal, pressure, and forced), mass and moles transport, mass & molar average velocities; shell mass balances; concentration distribution through stagnant gas, diffusion in heterogeneous and homogeneous chemical reaction, falling film; Equations of change for multicomponent systems and concentration distribution in turbulent flows: derivation of equation of continuity for binary mixture.

Textbooks:

1. R.B. Bird, W.E. Stewart and E.W. Lightfoot, Transport Phenomena, 2nd Edition, John Wiley, 2002.

References:

1. R.S. Brodkey and H. C. Hershey, Transport Phenomena, McGraw Hill, 1988.
2. J.R. Welty, R.W. Wilson and C.W. Wicks, Fundamentals of Momentum, Heat, and Mass Transfer, 3rd Edition, John Wiley, 1984.
3. J.S. Slattery, Advanced Transport Phenomena, Cambridge University Press, 1992.

23CHE402 PROCESS DESIGN, INTEGRATION AND ECONOMICS L-T-P-C: 3-0-0-3

Pre Requisite(s): Process Heat transfer, Mass Transfer Operations I, Mass Transfer Operations II , Chemical Reaction Engineering

Course Objectives

The objective of the course is to enable the students to understand general design considerations of chemical process plants involving process development by bringing together the concepts of engineering and economics with the hierarchy of decisions in synthesis and analysis of a chemical process and its alternatives. The course also covers aspects of learn process integration with regard to energy efficiency, waste minimization and an efficient use of raw materials.

Course Outcomes

At the end of the course students would be able to:

CO1:	Make meaningful estimates on various economic aspects such as the capital investment, product cost, depreciation and profitability of an existing or new chemical process or project
CO2:	Apply heuristics to process design and synthesize flow sheets in accordance with the hierarchy of chemical of process design
CO3:	Apply heuristics and thermodynamic principles to separation system synthesis like distillation columns sequencing for ideal and non-ideal mixtures
CO4:	Explain the pinch concept to identify minimum energy targets, different choices and constraints during heat exchange networking, heat integration of process equipment.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3		1									3		3
CO2	3	3	3	3			1						3	3	3
CO3	3	3	3	3									3	3	3
CO4	3	3	3	3			1						3	3	3

Syllabus

Unit 1

Process Economics : Cash flows – Time value of money, Capital costs. Estimation of capital costs, manufacturing costs and working capital, Economic feasibility of project Depreciation - Methods of calulating depreciation.Profitability Analysis – Rate of return, Payback period, Discounted rate of return, Net present worth, Internal rate of return, Comparing investment alternatives. Break even analysis, Economic decisions in Chemical Plant – Economics of size – Essentials of economic balance –economic balance for insulation, evaporation, heat transfer

Unit 2

Chemical process design : Diagrams for understanding chemical processes. Design Process – steps in process design, primitive problem, Base case design, detailed design. Hierarchy of chemical process design. Newdesign vs. retrofit, approaches, Batch versus continuous processes. Heuristics for process design. Structure and hierarchical synthesis of flow sheets - Input-Output Structure of Flowsheet, Recycle Structure of Flowsheet, Hierarchy of decisions

Process conditions : conditions of special concerns for operation of reactor and separation systems – Temperature, Pressure etc.

Unit 3

Separation system Synthesis – Guidelines for choosing separation operations, General structure of the separation system, location of vapor and liquid recovery system in the process. Distillation column sequencing for ideal liquid mixtures and azeotropic distillation.

Heat Integration - Heat Exchanger Network, Pinch Analysis concept, Composite temperature – Enthalpy diagrams, Targets for minimum utilities, area, total cost.

Textbook(s)

1. Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz, Analysis, Synthesis, and Design of Chemical Processes, 3rdEdn, Pearson Education, 2008
2. Robin Smith, Chemical Process Design and Integration, John Wiley & Sons Ltd., New Delhi, 2014.

Reference(s)

1. Peters. M.S. and Timmerhaus, K.D., “Plant Design and Economics for Chemical engineering”, 4th Edition, McGraw Hill, Singapore, 1991.
2. Warren D. Seider, J. D. Seader, Daniel R. Lewin, Soemantri Widagdo, Product and Process Design Principles: Synthesis, Analysis and Design, 3rdEdn, Wiley, 2010
3. Harry Silla, Chemical Process Engineering Design and Economics, Marcel Dekker, Inc., New York, 2003
4. Douglas, J.M. “Conceptual Design of Chemical Processes”, McGraw-Hill, 1988.

23CHE403 PROCESS EQUIPMENT DESIGN PROJECT L-T-P-C: 2-0-3-3

Pre-Requisites: Chemical Process Calculations, Energy balance and Thermodynamics, Fluid and Particle Mechanics, Process Heat Transfer, Mass Transfer Operations I, Mass Transfer Operations II

Course Objectives

The objective of this course is to give a foundation for the undergraduates in the design of equipment used in process industries for the unit operations heat transfer, evaporation and evaporative cooling. This course includes sizing of equipment and selection of the internal parts. It also covers the use of standards and codes for the design of equipment.

Course Outcomes

After this course, students will be able to

CO1	Propose the design of pressure vessels, appropriate supports, storage tanks for a given requirement in accordance with Indian Standard Codes.
CO2	Design and sketch plate and packed tower columns for distillation, extraction, absorption, and stripping.
CO3	Develop the mechanical design of different types of heat exchangers and evaporator for a given duty with the help of a detailed sketch
CO4	Develop the process design of dryer and crystallizers for a given feed solution and terminal conditions

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1						1				3	3	1
CO2	2	2	3			1			2				3	3	1
CO3	2	2	3			1			2				3	3	1
CO4	2	2	3			1			2				3	3	1

Syllabus

Unit 1
Design of process equipment: Pressure vessels, Pressure vessel codes, Design of shell and different types of heads, vessel closure, Supports; Storage vessels: nozzles and mountings. Mechanical Design using software

Unit 2
Design of mass transfer equipment for distillation, absorption and extraction: Column sizing, design of trays, column internals, plate hydraulic design for tray columns, packed column design, Design of Crystallizer, Design of different types of dryers, Mass transfer equipment design using software

Unit-3

Mechanical design of double pipe heat exchanger, shell & tube heat exchanger and condensers with pressure drop calculations. Design of evaporators – single and multiple effect evaporators,Heat Exchanger/Evaporator design using software

Textbook(s)

1. M.V Joshi and V V Mahajan, "Process Equipment Design"3rd Edition, McMillian India Ltd.,1996
2. S B Thakore and B I Bhatt, "Introduction to Process Engineering and Design" 1st Edition, Mc-Graw Hill Publications

Reference(s)

1. Sinnott R. K.; "Coulson and Richardson's Chemical Engineering Series", Vol. VI, 4th Ed., Asian Books Pvt Ltd,India
2. I.S.:2825-1969, "Code for Unfired Pressure Vessels"
3. Kern, D.Q., Process Heat Transfer, International Student Edition,McGraw Hill (2002).
4. Bhattacharyya, B.C., Introduction to Chemical Equipment Design, Mechanical Aspects, CBS Publishers and Distributors (2009).
5. Brownell, L.E. and Young, E.H., Process Equipment Design, Wiley India (P.) Limited (2004).
6. Perry, R.H. and Green, D, Chemical Engineer's Handbook, 8th Edition, McGraw Hill, New York. (2008)

23CHE497* INPLANT TRAINING/ INTERNSHIP* L-T-P-C: P/F

Prerequisite(s): Nil

Course Objectives

1. To expose the students to industry setting and get acquainted with its various functions.
2. To gain direct experience so as to relate and reinforce the concepts learned in the class room
3. To promote collaboration between industry and the institution

Course Outcomes

After the completion of this course, student will be able to

CO1:	Familiarize with the industry environment
CO2:	Realize the application of theoretical concepts in a practical setting.
CO3:	Prepare technical documents and give oral presentations related to the work completed.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1				2	2	2	2	2	2	2	1	2		
CO2	3	2			2		2		1			2			2
CO3	2	2						2	2	3		1		3	

Syllabus

Students have to undergo minimum of one week of practical training in Chemical Engineering or allied industries of their choice with the approval of the department. At the end of the training student should submit a report to the department in the prescribed format.

Evaluation Pattern

This course is mandatory and a student has to pass this course to be eligible for the award of degree. The committee constituted by the department will assess the student based on the report submitted and the presentation made.

Assessment	Internal	External
*Continuous Assessment (CA)	60	
**End Semester		40

•Continuous Assessment: Evaluation of the report prepared during training

*End Semester: Seminar / Viva voce

23CHE481 CHEMICAL PROCESS SIMULATION LABORATORY L-T-P-C: 2-0-3-3

Pre-Requisites: Chemical Process Calculations, Energy Balance and Thermodynamics, Chemical Engineering Thermodynamics, Process Heat Transfer, Mass Transfer Operations – I Mass Transfer Operations – II, Chemical Reaction Engineering

Course Objectives:

Students will learn the fundamentals of a process simulation software along with the equations and solution strategies required for solving different types of problems in Chemical processes. In all these simulations, Chemical Engineering Thermodynamics will be used to estimate the properties. After learning simulation of individual equipment, students will simulate full flow sheet of a process given to them.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Explain the basic structure of any process simulation software design and rating problems
CO2:	Formulate governing equations for a process based on conservation principles to estimate the degrees of freedom for a stream, equipment and process
CO3:	Develop and simulate a process flow sheet based on given problem statement using Aspen HYSYS Software
CO4:	Perform case studies for a chemical process using Aspen HYSYS Software

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	2	3								3	2	
CO2	3	3	3	3	3								3	3	3
CO3	3			3									3	3	3
CO4	3	3	3										3	3	3
CO5	3	3	3		3								3	3	3

Syllabus

Introduction to Aspen Plus / HYSYS; Thermodynamics Property methods; Solution strategies; Simulation of Pressure Changing devices (Pumps, Compressors and Turbine); Simulation of Two-phase and Three phase Separation units; Simulation of heat exchangers; simulation of reactors (Plug flow, mixed-flow, conversion, Gibbs and Equilibrium reactors and their combinations); Simulation of distillation, absorption and extraction columns; Dynamics of process equipment; Flow sheet simulations with recycle; Case study and sensitivity analysis; Additionally, the process chosen in Project Based Learning will be simulated in this course.

Textbook(s)

1. Gil Chaves, I.D., López, J.R.G., García Zapata, J.L., LeguizamónRobayo, A., Rodríguez Niño, G, Process

2. Analysis and Simulation in Chemical Engineering, Springer, 2016
3. Rutherford Aris, Elementary Chemical Reactor Analysis, Butterworths Series in Chemical Engineering, 1989

Reference(s)

1. Ralph Schefflan, Teach Yourself the Basics of Aspen, 2015
2. Aspen Hysys Manual, Free Source from Aspen One

23CHE482 CHEMICAL PROCESS CONTROL AND INSTRUMENTATION LABORATORY

L -T-P-C : 0-0-3-1

Pre-Requisites: Process Dynamics and Control

Course Objectives

The chemical process control provides hands-on practical training on understanding and operating chemical processes to obtain data for analyzing dynamics of the process, employ different controller configurations and control schemes for chemical processes and perform controller tuning. This instrumentation lab familiarizes the student how to perform accurate analytical/quantitative measurements by using instruments and estimate the error in measurement using measurement systems analysis.

Course Outcomes

After the completion of the lab the student will be able to

CO1:	Apply the principles behind the process instrumentation to carry out measurements, perform Gauge R&R analysis and test the suitability of an instrument for a given process.
CO2:	Interpret transient response characteristics of first order system, first order systems in series, second order system and control valves to calculate system parameters
CO3:	Analyse the response of control systems (level, flow, pressure etc) in feedback and advanced control configurations for various controller parameter settings.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3			3				3	2	1		3	2	2
CO2	3	3		3	3				3	3			3	3	3
CO3	3	3		3	3				3	3			3	3	3

Syllabus

Chemical Process Control Lab : Dynamic response of first order, second order, interacting and non-Interacting systems, Transient response of feedback control characteristics (different control configurations) for level, pressure, flow control etc., Controller tuning, Advanced Control Strategies (cascade, ratio, feed forward), Control valve characteristics; IoT enabled control systems

Chemical Engineering Instrumentation: Helicopter Gage R&R, temperature measurement; pressure measurement; Flow measurement; Concentration measurement; IoT with SCADA for temperature measurement.

Reference(s)

1. G.S. Patience, Experimental Methods and Instrumentation for Chemical Engineers, Elsevier, 2013
2. V.R. Radhakrishnan, Instrumentation and Control for the Chemical, Mineral and Metallurgical Processes, Allied Publishers Pvt. Ltd., 1997
3. Alok Barua, Fundamentals of Industrial Instrumentation, Wiley India, 2011

4. Donald R. Coughanowr, Steven E. LeBlanc, “Process Systems Analysis and Control – 3rdEdn., Tata Mcgraw Hill Education, 2011.

23CHE498 PROJECT PHASE I L-T-P-C: 0-0-6-2

Course Objectives

To execute a chemical engineering project to understand and to apply various concepts studied throughout the course.

Course Outcomes

After the completion of this course, student will be able to

CO1:	Create a set up through proper design and investigate the system using the engineering knowledge acquired
CO2:	Estimate and manage the cost and time of the project
CO3:	Present the project with clarity and ethics in both oral and written mode
CO4:	Develop a team and effectively participate in the team to execute the project
CO5:	Support the environmental, social and engineering discipline through the project

CO-PO-PSO Mapping: [affinity$^{\#}$: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3								3	3	3
CO2											3		3	3	
CO3								3	3	3			3		3
CO4									3				3		3
CO5						3	3					3	3		3

Syllabus

Identification of the problem based on the current need gaps of the industry/knowledge/other academic/theoretical aspects; literature survey, identification of the project deliverables, identification of materials/equipment requirements, preparation of the methodology for the experimentation and procurement of the materials. Presentation of project progress report to the department for evaluation at the end of the semester.

SEMESTER 8

23CHE499 PROJECT PHASE II L-T-P-C: 0-0-30-10

Course Objectives

To execute a chemical engineering project by applying the various concepts studied throughout the course.

Course Outcomes

After the completion of this course, student will be able to

CO1:	Create a set up through proper design and investigate the system using the engineering knowledge acquired
CO2:	Estimate and manage the cost and time of the project
CO3:	Present the project with clarity and ethics in both oral and written mode
CO4:	Develop a team and effectively participate in the team to execute the project
CO5:	Support the environmental, social and engineering discipline through the project

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3								3	3	3
CO2											3		3	3	
CO3								3	3	3			3		3
CO4									3				3		3
CO5						3	3					3	3		3

Syllabus

Identification of the problem based on the current need gaps of the industry / knowledge / other academic / theoretical aspects; literature survey, identification of the project deliverables, identification of materials/equipment requirements, preparation of the methodology for the experimentation and procurement of the materials. Presentation of project progress report to the department for evaluation at the end of the semester.

PROFESSIONAL ELECTIVES

23CHE331 ADVANCED SEPARATION PROCESSES L-T-P-C: 3-0-0-3

Course Objectives

Separation techniques are integral unit operation in most of the chemical, pharmaceutical and other process plants. The separation processes, like, membrane based techniques, and chromatographic separations are gaining importance in plants. The present course is designed to emphasize on these advanced separation processes.

Course Outcomes

After the completion of the course the student will be able to

CO1:	Perform basic design of multi component distillation columns with multiple feed streams synthetic membranes and membrane modules
CO2:	Describe the structure, characteristics and operational features of different types of synthetic membranes and membrane modules
CO3:	Explain the characteristic features, applications, limitations and advantages of separation operations like filtration, reverse osmosis, electrodialysis, pervaporation, gas separation and chromatographic separations
CO4:	Describe the governing principles and characteristic features of combined reaction and separation techniques, ionic separations, supercritical fluid extractions , industrial effluent treatment, reactive extraction and reactive distillation

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2		2								2	2	
CO2	3		2										3		
CO3	3	2	2		2		1						3	2	
CO4	3		2				1						3		

Syllabus

Unit 1

Introduction to binary distillation – The concept of K-factor; Multi-component distillation –Design, Models for multi-component design; Design of distillation columns for more than one feed stream; Pressure drop and tray-efficiency calculations

Unit 2

Nature of Synthetic Membranes, General membrane Equation, Cross-Flow Microfiltration, Ultrafiltration, Reverse Osmosis, Membrane Modules and Plant Configuration, Membrane Fouling, Electrodialysis, Reverse Osmosis Water Treatment Plant, Pervaporation, Liquid Membranes

Gas Separations - Chromatographic Separations: Elution Chromatography, Band Broadening and Separation Efficiency, Types of Chromatography, Large Scale Elution Chromatography, Selective Adsorption of Proteins, Simulated Counter current Techniques, Pressure Swing Adsorption

Unit 3

Combined Reaction and Separation, comparison with other separation techniques - Ionic Separations: Ion Exchange Resins, Resin Capacity, Equilibrium, Exchange Kinetics; Ion Exchange Equipment - Other Techniques: Supercritical Fluid Extraction, Oil Spill Management; Industrial Effluent Treatment by Modern Techniques. Reactive Extraction and Reactive Distillation

Textbook(s)

1. J.D. Seader and E.J. Henley, “Separation Process Principles“, 2nd Edition, Wiley, 2005.
2. J.M. Coulson and J.F. Richardson, “Chemical Engineering - Volume 2“, 5th Edition, Butterworth-Heinemann, 2002.

Reference(s)

1. R.W. Baker, “Membrane Technology and Applications“, John Wiley & Sons Ltd, UK, 2004.
2. P.C. Wankat, “Separation Process Engineering”, 2nd Edition, Prentice Hall, 2006.
3. R.W. Rousseau, “Handbook of Separation Process Technology”, Wiley-Interscience, 1987.
4. Y. Osada and T. Nakagawa, “Membrane Science and Technology”, Marcel Dekker, 1992.
5. Relevant journal publications.
6. Warren L. McCabe, Jullian Smith C. and Peter Harriott, Unit Operations of Chemical Engineering, McGraw-Hill, New York, 2001.

23CHE332 ARTIFICIAL NEURAL NETWORKS IN CHEMICAL ENGINEERING L-T-P-C: 3-0-0-3

Pre-Requisites: None

Course Objectives

This course aims to introduce the principles of artificial intelligence, particularly those of artificial neural networks, to undergraduate chemical engineering students. Specific objectives include:

- Facilitate understanding of foundations of artificial intelligence.
- Understand and be able to apply linear neuron models for regression and prediction problems.
- Understand and be able to apply nonlinear neuron models for nonlinear regression problems.
- Understand and be able to apply neural networks for classification problems.

Course Outcomes

After this course, students will be able to

CO1	Demonstrate understanding of the principles, components, learning and performance analysis of artificial intelligence and artificial neural networks.
CO2	Apply linear neuron models for linear regression and prediction problems, including in chemical engineering.
CO3	Apply multilayer perceptron and nonlinear neuron models for nonlinear regression problems, including in chemical engineering.
CO4	Apply neural networks to solve classification problems, including in chemical engineering

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	2	3	2	3	3								1	1	
CO2	2	3	2	3	3								1	1	
CO3	2	3	2	3	3								1	1	
CO4	2	3	2	3	3								1	1	

Syllabus

(Note: The course is taught at an introductory level, with more emphasis on the application of artificial intelligence to solving chemical engineering problems.)

Unit 1

Introduction to Artificial Intelligence – Rational Agents, Task Environments, Structure of Agents, Representation of States and Transitions; Knowledge Representation, Reasoning, and Inference; Propositional Logic and Logical Equivalence; Predicate Logic and Quantification; Problem-Solving Agents: Formulating Problems

Artificial Neural Networks (ANN) – Perceptron, Layers; Features of a Node – Inputs, Outputs, Weight Factors, Thresholds, Transfer Functions; Topology – Intra-, Inter-layer, Recurrent, Feedback, Feedforward; Learning – Stability and Convergence; Supervised, Unsupervised and Reinforcement Learning; Deep Learning using ANN

Unit 2

Linear Neuron Model: Model, Training with Delta Rule, Performance Parameters; Applications in Linear Regression, Linear Classification and Prediction; Applications to Multilinear Regression in Chemical Engineering; Visualization of Regression using ANN

Nonlinear Regression using Neural Networks: Multilayer Perceptron, Nonlinear Neurons; Applications in Chemical Engineering; Backpropagation Algorithm; Selecting the Hidden Layers, Weights; Use of Software Tools – MATLAB

Unit 3

Classification using Neural Networks: Pattern Classifiers – Parametric, Non-parametric, Similarity, Discriminant; Network Architecture, Classification Algorithms in the Network; Performance – Logistic Regression, Transition Region, Boundary; Applications in Chemical Engineering – Fault Diagnosis, Feature Categorization; Use of Software Tools – MATLAB

Textbook(s)

1. S. Russell, P. Norvig, "Artificial Intelligence: A Modern Approach", Fourth Edition, Prentice Hall, 2010.
2. S. Samarasinghe, "Neural Networks for Applied Science and Engineering", Auerbach Publications, 2007.
3. D. R. Baughman, Y. A. Liu, "Neural Networks in Bioprocessing and Chemical Engineering", Academic Press, 1995.
4. J. Ren, W. Shen, Y. Man, L. Dong (editors), "Applications of Artificial Intelligence in Process Systems Engineering", Elsevier, 2021.

Reference(s):

1. C. C. Aggarwal, "Artificial Intelligence: A Textbook", Springer, 2021.
2. Recent articles on applications of ANN in Chemical Engineering (case studies)

23CHE333 BIOCHEMICAL ENGINEERING L-T-P-C: 3-0-0-3

Pre-Requisites: Chemical Process Calculations, Fluid and Particle Mechanics, Process Heat Transfer, Chemical Reaction Engineering

Course Objectives:

To apply the chemical engineering principle in biological systems and to study the role of enzymes and microbes in biotechnology sectors.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Understand the basics of biomolecules and microbes to study different biochemical reactions.
CO2:	Study the basic concepts and kinetics of enzyme and immobilized enzyme
CO3:	Design and analyze the bioreactors
CO4:	Understand the downstream processing and industrial bioreactors

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO2	PSO3
CO	1	1					1						1	1	
CO2	3	3					1						3	3	
CO3	3	3	2				1						3	3	
CO4	3	3	2				1						3	3	

Syllabus

Unit 1

Introduction: History and need for biochemical Engineering; Essential life sciences: Biomolecules; Microbial world; Metabolism and Bioenergitics; Cell and their function;Enzymes and enzyme kinetics : Enzymes fundamental concepts, Classification of enzymes; Industrial application of enzymes; Industrially important enzymes; Mechanism of enzymatic reactions; Kinetics: Michaelis-Menten and Briggs Haldane equation; Evaluation of kinetic parameters; Enzymes inhibition; Factors affecting the reaction rates;

Unit 2

Immobilized enzyme: Medical and analytical application of immobilized enzyme; Techniques; Immobilized Enzyme kinetics: Effect of mass transfer resistance.Microbial kinetics : Typical growth characteristics of microbial cells, factors affecting growth; Monod's equation; Transport in microbial system : Newtonian and Non-Newtonian behaviour of broths; Agitation and Mixing; Power consumption; Gas – Liquid transport in cells; Transfer resistances; Mass transfer coefficients and their role in scale – up of equipments.

Unit 3

Bioreactors: Batch and continuous types; High performance bioreactors; Downstream processes and effluent treatment: Recovery and purification of products, different unit operations in down streaming with special reference to membrane separations; Extractive fermentation; Anaerobic treatment of effluents; Typical industrial examples for downstream processing and effluent disposal.

Textbook(s)

1. J. E Bailey and D. F. Ollis, "Biochemical Engineering Fundamentals", McGraw Hill, International Edition, 2nd Edition, New York, 1986.

Reference(s)

1. J. M.Lee, "Biochemical Engineering", 1st Edition, Prentice Hall, 1992
2. H. W. Blanch and D.S.clark, "Biochemical Engineering", 2nd Edition,CRC Press, 1997.
3. M.L.Shuler and F. Kargi , "Bioprocess Engineering Basic Concepts", Prentice Hall of India,2002.
4. D Mukesh and N.G.Sathyanarayana, "Biochemical Engineering", PHI Learning Pvt. Ltd., 2007

23CHE334 **BIOMATERIALS** **L-T-P-C: 3-0-0-3**

Course Objectives

- Introduce basic structure and properties of different classes of materials.
- Introduce the basics of molecular and cellular host responses and biocompatibility testing.
- Apply the understanding of materials and biocompatibility in designing materials and devices for some biomedical applications.

Course Outcomes

After the completion of this course, student will be able to

CO1:	Apply the understanding of materials and biocompatibility in designing materials and devices for some biomedical applications
CO2:	Design materials for biomedical applications including cardiovascular, ophthalmologic, orthopedic, dental and other applications
CO3:	Interpret the results from common materials characterization instruments.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	1	2		1	3				1					
CO2	2	1	2		1	3				1					
CO3	2	1	1		1					1					

Syllabus

Unit 1

Introduction to Biomaterials –Overview of the Biomedical Product Development Process and Regulation. Basics of Material Structure, Overviews of Metals, Polymers, Ceramics and Natural Materials used in Biomedical Engineering. Surface Modification Methods. Properties and Characterization of Materials.

Unit 2

Structure, Function and Adhesion of Proteins, Cell-Surface Interactions, Blood-Materials Interactions, Molecular and Cellular Host Responses, Biocompatibility, Degradation of Biomaterials, Testing of Biomaterials.

Unit 3

Biomedical Applications of Materials in the Areas - Cardiovascular, Orthopedic, Ophthalmologic, Dental Implants, Sutures, Burn Dressings, Adhesives & Sealants, Bioelectrodes, Biomedical Sensors & Biosensors, Tissue Engineering and Scaffolds.

Textbook(s)

1. Ratner B D, Hoffman A S, Schoen F J and Lemons J E, Biomaterials Science: An Introduction to Materials in Medicine, Third Edition, Academic Press, 2012.

2. Hill D, Design Engineering of Biomaterials for Medical Devices, John Wiley, 1998.

23CHE335 BIOPROCESSING AND BIOSEPARATIONS L-T-P-C: 3-0-0-3

Course Objectives:

The course focusses on upstream and the other on downstream sections of bioprocessing concepts. It provides students with the necessary insight of the fundamentals of biocatalysis, fermentation and bioreactor engineering design for the production of high value bio-products. The course also provides students with the necessary insight of the fundamental principles and common practices of downstream operations to enable recovery and purification of biologics and high value products.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	To impart knowledge on operation of fermentation processes and basics of bioreactor engineering
CO2:	To learn and apply the basics of enzyme and immobilized enzyme kinetics.
CO3:	To learn and apply the basics of microbial kinetics, metabolic stoichiometry and energetics.
CO4:	To learn the unit operations in biochemical processes and study the production of biochemical product using integrated biochemical processes.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	1		2	2						3	3	
CO2	3	3	3	1		2	2						3	3	
CO3	3	3	3	1		2	2						3	3	
CO4	3	3	3	1		2	2						3	3	

Syllabus

UNIT 1

Bioprocessing and Bioseparations : Raw Materials, Media Design, Process Conditions Required, Sterilization Kinetics (batch and continuous), Bioreactors: Configuration and Scale up, Bioreactor consideration in enzyme systems, Recombinant cell cultivation

UNIT 2

Enzyme: Introduction, Mechanism, characterization of active and ligand binding sites, kinetics; Inhibitor: Types, Kinetics; Immobilisation: Methods, Diffusional Limitations, Electrostatic Effects; Industrial Utilization of Enzymes. Kinetics of microbial growth and product formation (batch and continuous),

UNIT 3

Metabolic stoichiometry and energetics.

Downstream Processing: Introduction, Principles, Cell Disruption Methods, Pretreatment, Stabilization, Unit Operations (Solid-Liquid Separation, Liquid-Liquid Separation), Purification and Formulation

Textbook(s)

1. Shuler, Michael L. and Fikret Kargi, " Bioprocess Engineering ", Prentice Hall, 1992.
2. Doran, Pauline "of Bioprocess Engineering Principles ". Elsevier, 1995
1. Belter, P.A., E.L. Cussler and Wei-Houhu "Bioseparations – Downstream Processing for Biotechnology", John Wiley, 1988.
5. Sivasankar, B. "Bioseparations: Principles and Techniques". PHI, 2005.
6. Asenjo, Juan A. "Separation Processes in Biotechnology". CRC / Taylor & Francis, 1990.

Reference(s)

1. Lydersen, Bjorn K. "Bioprocess Engineering Systems, Equipment and Facilities" John Wiley, 1994.
2. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, Principles of Fermentation Technology, Science & Technology Books.
3. Anton Moser, "Bioprocess Technology, Kinetics and Reactors", Springer Verlag.
4. Ghosh, Raja "Principles of Bioseparations Engineering". World Scientific, 2006
5. "Product Recovery in Bioprocess Technology". (BIOTOL – Biotechnology by Open Learning Series). Butterworth – Heinmann / Elsevier, 2004.

23CHE336 CATATYSIS SCIENCE AND ENGINEERING L-T-P-C: 3-0-0-3

Pre-requisite(s) : None

Course Objectives:

Student will be taught about various types of catalytic reactions and catalytic materials that are used in industrial processes followed by important catalytic characterization techniques and different ways in which the performance of the catalyst degradation. Students will also learn how to estimate the kinetic parameters of catalytic reaction and how to design and prepare catalysts for specific reactions.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Explain different ways of preparation and Characterization of different types of heterogenous catalysts used as industrial catalysts using surface analysers and thermal techniques
CO2:	Develop reaction mechanisms for catalytic reactions based on adsorption, desorption and surface reaction phenomena
CO3:	Estimate parameters in kinetic reaction models for catalytic reactions from experimental data
CO4:	Analyse the effect of catalyst deactivation and its type on catalyst performance
CO5:	Select and design good catalysts for a given reaction

CO-PO-PSO Mapping: [affinity[#]: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3											3	3		
CO2	3	3											3		
CO3	3	3	3		3								3	3	3
CO4	3	3	3	3	3								3	3	3
CO5	3	3	3	3								3		3	3

Syllabus

Unit 1

Introduction to catalysis; adsorption in solid catalysis; adsorption types and kinetics; multilayer adsorption and pore condensation Heterogeneous catalysis: Solid catalysis, types of catalysts, catalyst formulations, preparation, and characterization methods (BET surface area analysis and chemisorption techniques). Testing of catalysts, various types of reactors, activity, and selectivity studies. Catalysts in steam reforming and petroleum refining.

Unit 2

Different reaction types; mechanism and kinetics of adsorption, desorption, surface reactions, rate-determining steps. Kinetic modeling and parameter estimation and model discrimination; catalyst promoters, Inhibitors and catalyst deactivation, kinetics of catalyst deactivations. Determination of coke and its types using thermal analysis and Temperature programmed Oxidation Techniques.

Unit 3

Industrial homogeneous process; Enzyme catalysis, Emerging catalysis: Zeolites catalysts; Polymerization catalysts; Carbon nanotubes; Nano metal or metal oxide catalysts; Phase transfer catalysts; Fuel cell catalysts, Environmental catalysts, Design of catalysis- supported and un-supported catalysts

Textbook(s)

1. B. Viswanathan, S. Sivasanker , A.V. Ramaswamy, "Catalysis : Principles & Applications" CRC Press
2. G. Ertl, H. Knozinger and J. Weitkamp, "Handbook of Heterogeneous Catalysis" Vol 1-5, Wiley - VCH.
3. R. J. Farrauto, C. H. Bartholomew, “Fundamentals of Industrial Catalytic Processes” Blackie Academic & Professional, 1997.

Reference(s)

1. J.J. Carberry, "Chemical and catalytic reaction Engineering,” Dover Publications.
2. H. S. Fogler, "Elements of Chemical reaction engineering" Prentice – Hall of India.

23CHE337 CFD IN CHEMICAL PROCESSES L-T-P-C: 3-0-0-3

Pre-Requisites: Numerical Methods in Chemical Engineering, Process Heat Transfer, Chemical Reaction Engineering

Course Objectives:

The students will understand basics of process intensification and its application to chemical engineering, to reduce the cost of operation by improving the rates of heat transfer, mass transfer, reactions and separations and how to overcome equilibrium limitations, therefore the reactions can be conducted in kinetically controlled regimes.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Explain the experimental, analytical and computational approached for solving fluid dynamic problems
CO2:	Develop governing equations for fluid dynamics and reaction engineering problems using conservation laws
CO3:	Analyze the stability of the discretized governing equations to obtain stability criterion
CO4:	Simulate the fluid dynamic and reaction engineering problems using user-developed computer programs and commercial software

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3												3		
CO2	3	3											3		
CO3	3	3	3		3							2	3	3	3
CO4	3	3	3		3							2	3	3	3

Syllabus

Unit 1
Introduction to Computation Fluid Dynamics (CFD) – a research, modelling and design tool – historical perspective – experimental, analytical and computational approaches for flow and heat transfer process

Unit 2
Commercial CFD packages – Mathematical description of physical phenomena – Governing Differential equations of fluid flow and heat transfer – transport equations and their classification – various discretization methods – finite difference, finite element and finite control volume methods – Choice of discretization – Stability analysis of discretization methods;

Unit 3

Solving Fluid Dynamic problems with commercial software: Introduction to numerical grid generation – structures and unstructured grid generation methods – automatic grid generation; conservation law of fluid motion, boundary conditions, turbulence modelling, diffusion problems, convection problems, combined diffusion and convection problems, pressure velocity coupling in steady flows, simulation of unsteady flows, Coupled heat transfer and reaction engineering problems

Textbook(s)

1. H.K. Versteeg and W. Malalasekera, "An Introduction to Computational Fluid Dynamics – The Finite Volume Method", Pearson Education, 2nd Edition, 2008
2. J.D. Anderson, "Computational Fluid Dynamics", MGraw-Hill Publishers, 1995

Reference(s)

1. A.W. Date, "Introduction to Computational Fluid Dynamics", Cambridge University Press, 2005
2. S.V. Patankar, "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 1990

23CHE338 CHEMICAL ENGINEERING SOFTWARE DEVELOPMENT L-T-P-C: 3-0-0-3

Pre-Requisites: 1. Computer programming and Algorithmic Problem solving or Computer Programming or Python programming, Chemical Process Calculations, Chemical Engineering Thermodynamics, Chemical Reaction Engineering

Course Objectives

Students will learn about basics of different components of an end-end-to simulation of a process equipment starting from how the properties are calculated based on process variation, parameters required for property calculations, duty calculations, equipment size etc.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Develop solution algorithms for the equations encountered in Chemical Engineering
CO2:	Explain different methods of data transfer between the user and the software
CO3:	Develop a simulator for any one of the process equipment, including parameter estimation and property calculations

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3			3							3	3	3	
CO2		2			3				2					3	
CO3					3				2			3	3	3	

Syllabus

Unit 1
Properties of the data entry choices; data transfer between main program and its subroutines; Definition of Global variables;

Unit 2
Algorithms for equations encountered in Chemical Engineering, Subroutines relevant to Chemical Engineering, Dynamic stream creation, data transfer and retrieval; Introduction to database development for thermodynamic property calculations;

Unit 3

Algorithms for equations encountered in Chemical Engineering, Subroutines relevant to Chemical Engineering, Dynamic stream creation, data transfer and retrieval; Introduction to database development for thermodynamic property calculations;

Textbook(s)

1. H.K. Versteeg and W. Malalasekera, “An Introduction to Computational Fluid Dynamics – The Finite Volume Method”, Pearson Education, 2nd Edition, 2008
2. J.D. Anderson, “Computational Fluid Dynamics”, MGraw-Hill Publishers, 1995

Reference(s)

1. A.W. Date, “Introduction to Computational Fluid Dynamics”, Cambridge University Press, 2005
2. S.V. Patankar, “Numerical Heat Transfer and Fluid Flow”, Hemisphere Publishing Corporation, 1990

23CHE339 CHEMICAL PROCESS MODELING AND SIMULATION L-T-P-C: 3-0-0-3

Pre-Requisite(s): Chemical Process Calculations, Energy Balance and Thermodynamics, Chemical Engineering Thermodynamics, Fluid and Particle Mechanics, Mass Transfer Operations I & II, Chemical Reaction Engineering

Course Objectives

This course will lay the foundations of chemical process modeling and simulation based on a systems approach, summarizing the core concepts learned in the various chemical engineering courses and using them to build predictive and control models of chemical processes that reveal interesting underlying physics of the processes. A systematic approach will be developed for modeling and simulation, involving the following aspects:

- Recognizing and rigorously formulating the physics/chemistry of a process as a mathematical model,
- Making judicious assumptions that do not compromise but instead highlight the essential physics, and,
- Developing simple mathematical models of chemical systems and analyzing them, gradually leading to more complex models.

In applying the principles of chemical systems modeling to practical problems, there are at least two other aspects that are critical:

- Choosing model parameters that best capture the physics of the process, and estimating their sensitivity on the model behavior, and,
- Developing methods of validating the model against appropriately designed experiments.

These will not be a focus of this introductory course. However, together, the five aspects listed above constitute a reasonable systematic approach to modeling chemical engineering problems. Once this approach has been developed, starting from the simplest linear problem of filling and draining a cylindrical tank, the course will introduce modeling in single dimension followed by modeling of multiscale and nonlinear processes. Finally, this course will introduce to the students the basic principles of flowsheet simulation.

Course Outcomes

After the completion of this course, student will be able to

CO1:	For a given chemical system, recognize the various processes taking place whose relative rates will influence system performance. Identify the characteristic scales appropriate to the system and processes and derive dimensionless groups.
CO2:	For a given chemical system, write the appropriate conservation and constitutive equations that determine the rates of the processes or specify the equilibrium conditions for reversible processes taking place.
CO3:	Derive mathematical models for basic chemical engineering unit – lumped, distributed, and staged – operations and processes. Determine appropriate specifications of model parameters for a system to solve simple design and rating problems involving the system.
CO4:	For a process flowsheet, develop simulation algorithms using sequential modular approach and equation-oriented approach. Identify tear streams, determine the modules and propose simulation algorithms.

CO-PO-PSO Mapping: [affinity$^{\#}$: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3		1	2		3			3	3	3	3
CO2	3	3	3	3		1	2					3	3	3	3
CO3	3	3	3	3		1	2					3	3	3	3
CO4	3	3	3	3	3	1						3	3	3	3

Syllabus

Unit 1

Chemical engineering problems; Modeling – Steps involved; Variables – Stream, Unit, and Process variables; Constraints – Conservation relations, Sources and sinks, Material, Energy, Momentum balances; Equilibrium relations, Constitutive models; Common assumptions in modeling; Types of models – Lumped, Distributed, and Staged parameter models; Design variables – Characteristic length, time, velocity, temperature, mass, force; Change of variables; Dimensionless groups in modeling

Filling and draining tanks: Steady and unsteady states, Varying inlets and outlets, Level and flow control; Mixing tanks: Two and multiple streams, Composition control; Heated tank: Jacketed kettle with steam condensation, Electrical heating, Phase change; Isothermal CSTR: 1^{st} and 2^{nd} order reactions, Enzyme kinetics; Non-isothermal CSTR; Centrifugal separation

Unit 2

Shell balances: Flow through a pipe, Continuity equation; Compressible fluid flow, Shock waves; Double-pipe heat exchanger: Steam condensing in shell/tube, Parallel vs. counter flow; Pipeline flashing; Isothermal PFR: Component continuity equation, 1^{st} and 2^{nd} order reactions; Non-isothermal PFR: 1^{st} and 2^{nd} order reaction

Triple effect evaporator; Binary distillation: continuous and batch columns; Multicomponent distillation: Underwood-Gilliland model; Gas absorption into a laminar liquid jet; Tray tower absorption: Kremser-Brown-Sauders equation, rigorous models; Reactive absorption in a wetted wall column; Multistage countercurrent liquid-liquid extraction

Unit 3

Selected Systems from the following: Multiple steady states and Stability: Isothermal and Non-isothermal CSTR; Temperature control in a non-isothermal PFR; Packed bed reactor; Polymerization: Bulk and Suspension polymerization; Membrane separation – Cross flow and reverse osmosis; Activated sludge process – secondary bioreactor; Pyrolysis of plastic; Chemical vapor deposition; Continuous, multicomponent distillation column; Dry flue gas desulfurization; Ball mill; Rotary kiln

Flowsheet simulations: Sequential modular and Equation oriented approaches; Tear streams; Simulation approaches

Textbook(s)

1. W. L. Luyben, Process Modeling, Simulation and Control for Chemical Engineers, 2^{nd} Edition, McGraw Hill, 1996.
2. C. L. Smith, R. W. Pike and P. W. Murrill, Formulation and Optimization of Mathematical Models, International Textbook Company, USA, 1970.

3. L. T. Biegler, E. I. Grossman and A. W. Westerberg, Systematic Methods of Chemical Process Design, Prentice Hall, 1997.

23CHE340 CHEMICAL REACTOR DESIGN AND ANALYSIS L-T-P-C: 3-0-0-3

Pre-requisite(s) : Mass Transfer Operations I, Chemical Reaction Engineering

Course Objectives:

Students will learn about the important steps in heterogeneous reactions, obtain final rate expression based on rate determining step and examine the suitability of a rate expression for an experimental data obtained from packed bed and fluidized bed reactors. The students will also learn effect of catalyst parameters on reactor performance. These rate expressions along with heat and mass transfer will be used to design packed bed and fluidized bed reactors. Additionally, the students will analyse the effect of catalyst deactivation on reactor performance.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Derive rate expressions for catalytic and non-catalytic heterogeneous reactions based on different rate determining steps
CO2:	Design catalysts for heterogeneous reactions to eliminate pore diffusion and external mass transfer resistance using Thiele modulus, internal effectiveness factor, and external effectiveness factor
CO3:	Predict the effect of heat and mass transfer and catalyst deactivation in heterogeneous systems on reactor performance for isothermal and non-isothermal reactor operation
CO4:	Design heterogenous reactors for gas-solid, liquid-solid, gas-liquid, catalytic and non-catalytic reactions using material balance and heterogeneous reactors
CO5:	Analyze the effect of non-ideal mixing in reactors on mean residence time and reactor performance

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3											3		2
CO2		3		3									3		3
CO3				3	3								2	3	3
CO4			3												3
CO5				3									3		3

Syllabus

Unit 1

Review of homogenous chemical reactor design; Non-ideal mixing: Factors affecting the ideal mixing, residence time distribution (RTD), measurement of RTD – tracer injection analysis, Models for non-ideal flow

– Dispersion model and tanks-in-series model; Heterogeneous reactions – reaction rate definition; concentration profiles in heterogeneous reactions; effects of diffusion;

Unit 2

Solid catalyzed reactions – nature of catalysts, various resistances – adsorption and desorption, pore diffusion, surface reaction, rate-limiting step; surface area and pore volume distribution – methods of solid catalyst preparation; Gas-Solid catalytic reactions- Diffusion within the catalyst pellet, effective diffusivity and thermal conductivity, heat and mass transfer within the catalyst pellet, effectiveness factor and Thiele modulus; Extension Gas-Liquid-Solid reaction - Application and performance estimation of packed bed, fluidized bed and trickle bed reactors – Steam-methane reformation and Fischer-Tropsch Synthesis; Optimal Reactor configuration and scaleup; Modeling of multiphase reactors

Unit 3

Fluid-Solid non-catalytic reactions – kinetic models, volume and surface reactions, rate-limiting steps, time for complete conversion – Application to fuel oxidation and catalyst regeneration, Chemical vapor deposition and Microelectronics – Packed bed and Fluidized bed reactors; Dimensional Analysis and Reactor Scaleup; Biochemical Reactions and Reactor Design;

Textbook(s)

1. Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, John-Wiley Publishers, 1999
2. G.F. Froment and K.B. Bischoff, Chemical Reactor Analysis and Design, 2nd Edition, John-Wiley Publishers, 1990

Reference(s)

1. H.S. Fogler, Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall India, 2000
2. E. Bruce Nauman, Chemical Reactor design, Optimization and Scaleup, McGraw Hill Inc., 2002

23CHE341 COMPUTATIONAL MATERIALS SCIENCE L-T-P-C: 3-0-0-3

Pre-Requisites: None

Course Objectives

Course Outcomes

After this course, students will be able to

CO1 :	Classify molecular simulation approaches, understand their scope and applicability and determine the suitability of simulation approaches for materials engineering problems.
CO2 :	Understand the statistics in estimating macroscopic properties from molecular simulations and employ principles of thermodynamics and transport processes for the same.
CO3 :	Understand the quantum mechanical model of atoms, molecules and their interactions. Understand the principles and algorithms of quantum mechanical simulations such as Hartree-Fock, DFT, Ab Initio and Semi-Empirical simulations.
CO4:	Apply models of molecular interactions in molecular dynamics and Monte Carlo simulations, understand different algorithms in these simulations and minimization of energy. Gain hands-on skills in simulation techniques, analyse case studies and simulate model cases.
CO5:	Apply thermodynamics principles and Calculation of multi-component phase equilibria, precipitation modelling, segregation of elements, specific heat, latent heat data for solidification modelling.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

Syllabus

Unit 1

Definitions, Scope; Approaches for Molecular Simulation; Statistics – Estimating Macroscopic Properties from Molecular Simulations; Quantum Mechanics, Symmetry and Group Theory – Representing Molecules and Molecular Interactions; Molecular Orbital Theory; Hartree-Fock Approach; Introduction to Monte Carlo (MC) Simulations and Molecular Dynamics (MD); Minimization of functions – Advanced Energy Minimization Techniques.

Unit 2

Introduction to Unix; Software for Molecular Modeling (any two): GROMACS, ABINIT, ADUN, CP2K, CHARMM, DALTON, NAMD, LAMMPS, SPARTAN, TINKER; Programming Exercises (any five): Evaluation of Pi (MC), Pair-correlation functions, Integration using MC, MD of a simple fluid, MD of an excluded-volume polymer chain, 3D Visualization of Molecules, Model Building, Energy Minimization, Dynamics, Surface Properties, Thermodynamic Properties, Electronic Structure Calculations, Electronic Transport Properties; Case Studies

Unit 3

Review of thermodynamic equations & the concept of lattice stability, Introduction to solution thermodynamics & sub-lattice models & Basics of the CALPHAD methodology, Introduction to Thermo-Calc and CALPHAD software, Calculation of multi-component phase equilibria, precipitation modeling, segregation of elements, specific heat, latent heat data for solidification modeling, thermodynamic factors for constructing matrices for multicomponent alloys. Applications to real materials design such as superalloys, steels, Ti alloys, Al alloys, Mg alloys, Cu alloys, etc.

Textbook(s)

1. K. I. Ramachandran, D. Gopakumar and K. Namboori, "Computational Chemistry and Molecular Modeling: Principles and Applications", Springer, 2008.
2. T. Schlick, "Molecular Modeling and Simulation: An Interdisciplinary Guide", Springer, 2002.
3. D. Frenkel and B. Smit, "Understanding Molecular Simulations: From Algorithms to Applications", Second Edition, Academic Press, 2002.
4. M. P. Allen and D. J. Tildesley, Computer Simulation of Liquids, Clarendon Press, 1987. 5. Journal articles on molecular simulation of molecules of interest.
5. Nigel Saunders and A. Peter Miodownik CALPHAD: Calculation of Phase Diagrams, Pergamon, 1998

23CHE342 ELECTROCHEMICAL CONVERSION AND STORAGE DEVICES **L-T-P-C: 3-0-0-3**

Pre-Requisite(s): Materials Technology

Course Objectives

Electrochemical technologies – for energy conversion and storage as well as production – are among the most promising, sustainable and environmentally benign technologies. Given the extensive development and deployment of such technologies in the present and future, this course will introduce the students to the principles of electrochemistry, electroanalysis and various electrochemical technologies that are promising. Included will be batteries, supercapacitors, hydrogen production/storage and utilization (fuel cells), electrochemical production (chlor alkali, metal winning/refining), environmental and healthcare technologies.

Course Outcomes

After the completion of this course, student will be able to

CO1:	Explain the structure of electrolytes, electrodes, electrode-electrolyte interface (double layer). Develop and apply the principles of electrochemical thermodynamics.
CO2:	Develop rate expressions for electrochemical processes controlled by mass transfer and charge transfer (kinetics). Apply them to explain how polarization affects Faradaic and non-Faradaic processes at the electrode-electrolyte interface.
CO3:	Apply the principles of selected techniques, chronoampero/coulometry, linear sweep/cyclic voltammetry, pulse voltammetry, Tafel polarization and impedance spectroscopy for electroanalysis.
CO4:	Apply the principles of electrochemistry in energy generation, storage and utilization technologies, including primary and secondary batteries, supercapacitors, hydrogen production (photoelectrochemical and electrolytic) and fuel cells.
C**O5:**	Apply the principles of electrochemistry in production of materials, particularly chlor alkali & metal winning/refining, environmental (sensors and water treatment) and healthcare (sensors) applications.

CO-PO-PSO Mapping: [affinity$^{\#}$: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	2	2	1											
CO2	2	3	2	2											
CO3	2	3	3	3			1							2	
CO4	3	3	3	3	2	2	3		2			2		3	
CO5	3	3	3	3	2	2	3		2			2		3	

Syllabus

Unit 1

Electrolytes: Dissociation, Mobility, Transport Number; Ion-Solvent Interactions; Ion-Ion Interactions; Electrified Interface: Structure of Electrode-Electrolyte Interface – Non-Faradaic Processes, Thermodynamic Activity, Electrochemical potential and Nernst Equation; Mass Transfer in Electrolytes – Convection, Diffusion, and Migration; Diffusion-Controlled Processes

Unit 2
Electrode Kinetics – Butler-Volmer Equation, Marcus Theory, Tafel Equation, Polarization of Electrodes; Electroanalytical Techniques: Potential Step Methods – Chronoampero/coulometry, Potential Sweep Methods – Linear Sweep/Cyclic Voltammetry; Pulse Voltammetry – Normal Pulse, Differential Pulse, and Square Wave Voltammetry; Electrochemical Impedance Analysis

Unit 3
Electrochemical Energy Storage Technologies – Primary and Secondary Batteries; Chemistries of Lithium and Sodium Ion Batteries, Metal-Air Batteries; Supercapacitors – Principles and Materials Design Strategies; Hydrogen Technologies – Electrolytic and Photoelectrochemical Production; Storage; Fuel Cells – Types, Reactions and Designing Electrocatalysts

Chlor Alkali Membrane Technology; Electrodeposition – Metal Winning and Refining; Electrochemical Sensors for Water, Soil Quality and Healthcare; Electrochemical Technologies for Water Treatment – Electrooxidation and Reduction, Electrocoagulation, Capacitive Deionization.

***Text Books*:**

1. J. O'M. Bockris and A. K. N. Reddy, "*Modern Electrochemistry*" Volumes 1, 2A, and 2B, Second Edition, Kluwer Academic Publishers, NY, 2000
2. A. J. Bard and L. R. Faulkner, "*Electrochemical Methods: Fundamentals and Applications*", Second Edition, John Wiley and Sons, NY, 2001
3. V. S. Bagotsky, "*Fundamentals of Electrochemistry*", Second Edition, Wiley-Interscience, 2006.

23CHE343 ENVIRONMENTAL MANAGEMENT L-T-P-C: 3-0-0-3

Course Objectives:

The objective of the course is to make students interpret Environmental Management Systems according to ISO 14001 standards and develop possibilities within Environmental Management Systems

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Comprehend deeper knowledge about Environmental Management Systems (EMS).
CO2:	Practice Environmental Management Systems for Engineered systems for resources, energy recovery & material recovery
CO3:	Conduct Environmental Auditing for various Industries/Projects.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
COO1	3	2	2			2	2				1		2	1	2
COO2	3	2	2			2	2				1		2	1	1
COO3	3	2	2			2	2				1		2	1	1
COO4	3	2	2			2	2				1		2	1	1

Syllabus

Unit 1

Environmental Management Plan - preparation, implementation and review – Mitigation and Rehabilitation Plans – Policy and guidelines for planning and monitoring programmes – Post project audit – Ethical and Quality aspects of Environmental Impact Assessment- Case Studies, Rationale of Environmental standards: Concentration and Mass standards, Effluent and stream standards, Emission and ambient standards, Minimum national standards, environmental performance evaluation: Indicators, benchmarking

Unit 2

EMAS, ISO 14000 - EMS as per ISO 14001– benefits and barriers of EMS – Concept of continual improvement and pollution prevention - environmental policy – initial environmental review – environmental aspect and impact analysis – legal and other requirements- objectives and targets – environmental management programs – structure and responsibility – training awareness and competence- communication – documentation and document control – operational control – monitoring and measurement – management review.

Unit 3

Environmental management system audits as per ISO 19011- – Roles and qualifications of auditors - Environmental performance indicators and their evaluation – Non conformance – Corrective and preventive actions -compliance audits – waste audits and waste minimization planning – Environmental statement (form

V) - Due diligence audit . Applications of EMS , Waste Audits and Pollution Prevention opportunities in selected chemical process industries

Textbook(s)

1. Christopher Sheldon and Mark Yoxon, "Installing Environmental management Systems – a step by step guide" Earthscan Publications Ltd, London, 1999.
2. Environmental Management Systems: An Implementation Guide for Small and Medium-Sized Organizations, Second Edition, NSF International, Ann Arbor, Michigan, January 2001..
3. M. N Rao, "Waste Water Treatment" Oxford and IBH publishing Co. Pvt Ltd, 2007
4. Peavy, H.S, D.R. Rowe & T.George, "Environmental Engineering", New York: McGraw Hill, 1987

Reference(s)

1. ISO 14001/14004: Environmental management systems – Requirements and Guidelines – International Organisation for Standardisation, 2004
2. ISO 19011: 2002, "Guidelines for quality and/or Environmental Management System auditing, Bureau of Indian Standards, New Delhi, 2002
3. 4. Paul L Bishop „Pollution Prevention: Fundamentals and Practice‟, McGraw- Hill International, Boston,2000.

23CHE344 ENVIRONMENTAL RISK ASSESSMENT L-T-P-C: 3-0-0-3

Course Objectives:

The objective of the course is to make students understand concepts related to toxicology and characterize the specific hazard by accounting for variables, differing sensitivities, and uncertainties of analysis.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Identifying hazards, and risk assessment, i.e., describing and differentiating the public health risks, benefits, and costs of a particular action or chemical and thereby developing a framework for decision-making in environmental health and safety.
CO2:	Characterizing the public health risks of a specific hazard by accounting for variables, differing sensitivities, and uncertainties of analysis
CO3:	Define risk management and identify means to control risk including intervention as well as the use of legislative and regulatory guidelines.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
COO1	3	2	2			2	2				1		2	1	2
COO2	3	2	2			2	2				1		2	1	1
COO3	3	2	2			2	2				1		2	1	1
COO4	3	2	2			2	2				1		2	1	1

Syllabus

Unit 1

Overview of Environmental Risk Assessment, Environmental risk assessment framework-Hazard identification -Dose-Response Evaluation – Exposure Assessment – Dose-response assessment, Exposure Factors, Tools for Environmental Risk Assessment– HAZOP and FEMA methods – Event tree and fault tree analysis – Multimedia and multi-pathway exposure modeling of contaminant- Risk Characterization Risk communication - Emergency Preparedness Plans –Design of risk management programs-

Unit 2

Risk characterization, Issues in risk characterization, Risk estimation, Risk description, Default options in risk assessment uncertainty and variability. Toxicity testing methods and biomarkers, Exposure and Risk Mapping, Occupational Exposure and Risk Assessment

Unit 3

Understanding the legal and ecological risk exposures, Understanding human safety and health risk exposures 9. Understanding risk communication, Cutting edge issues in risk assessment, Case study: Ecological risk assessment Case study: Contaminants assessment Case study: Multiple Risk assessment

Textbook(s)

1. Cutter, S.L., "Environmental Risk and Hazards", Prentice-Hall of India Pvt. Ltd., New Delhi, 1999.
2. Kolluru Rao, Bartell Steven, Pitblado R and Stricoff "Risk Assessment and Management Handbook", McGraw Hill Inc., New York,1996.

Reference(s)

1. K. V. Raghavan and A A. Khan, "Methodologies in Hazard Identification and Risk Assessment", Manual by CLRI, 1990.
2. Sam Mannan, Lees' Loss Prevention in the Process Industries, Hazard Identification, Assessment and Control, 4th Edition, Butterworth Heineman, 2012.

23CHE345 GREEN CHEMISTRY AND ENGINEERING L-T-P-C: 3-0-0-3

Pre-Requisites: Engineering Chemistry

Course Objectives

Understanding basic chemical properties of materials and developing new materials and products for applications that are cost-effective, non-toxic, and environmentally friendly.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Adopt the twelve green chemistry principles and being able to apply them.
CO2:	Develop a problem-solving approach to green engineering.
CO3:	Application of appropriate technology to match a green engineering problem.
CO4:	Enforce the issues like environmental law, toxic and safety/ safe design.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	-	2	-	-	2	-	-	-	-	2	2	-
CO2	3	2	3	-	2	-	-	-	-	-	-	-	2	-	2
CO3	3	2	2	-	3	-	-	-	-	-	-	-	2	2	-
CO4	3	3	2	-	2	-	-	2	-	-	-	-	2	3	2

Syllabus

Unit 1

Green chemistry fundamentals : Green chemistry, tools, principles, and practice: 12 principles of green chemistry, nature of chemicals and world chemical scenario, waste prevention, atom economy, less hazardous chemical synthesis, methods to design safer chemicals, and future trends, measuring & controlling environmental performance, sustainable industrial chemistry.

Unit 2

Green technologies & processes: Catalysis & green chemistry, green product design, safer solvent, design for energy efficiency, renewable resource, reduce derivatives, Life cycle of product, ISO 14000, Environmental load of product, material selection, resource use, production requirements and planning for the final disposition (recycling, reuse or disposal) of a product.

Unit 3

Legal aspects & Case Studies: Design for degradation, real time analysis, accident prevention. International laws on take – back laws, extended responsibility, eco-labeling, Examples and case studies from pharmaceuticals, foods, cosmetics, packaging, computers, polymers, automobiles and electronics industry, designing greener processes, other case studies in green chemistry application.

Textbook(s)

1. “Green Chemistry-An introductory text”, by Mike Lancaster, Royal Society of Chemistry, Cambridge,2002 ISBN 0-85404-620-8.
2. “Green Chemistry: Theory and Practice” , by Paul T. Anastas and John C. Warne,Oxford University Press,2000.

Reference(s)

1. Martin Charter and Ursula Tischner,“ Sustainable Solutions: Developing Products and Services for the Future” , A Greenleaf Publishing book,2000.
2. Jay Warmke, Annie Warmke, “Green Technology” ,Educational Technologies Group, 2009.

23CHE346 HAZARDOUS WASTE MANAGEMENTS L-T-P-C: 3-0-0-3

Course Objectives:

The objective of the course is to make students understand concepts related to hazardous waste management and characterize hazardous wastes, and develop suitable treatment facilities.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Comprehend facts related to the characterization of hazardous wastes and the role of different stakeholders under the national legal framework
CO2:	Explain basic concepts related to the minimization of hazardous wastes
CO3:	Analyze the design of facilities for the storage, transport, processing, and disposal of hazardous wastes

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

Po/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
COO1	3	2	2			2	2				1		2	1	2
COO2	3	2	2			2	2				1		2	1	1
COO3	3	2	2			2	2				1		2	1	1
COO4	3	2	2			2	2				1		2	1	1

Syllabus

Unit 1

Hazardous waste definition– Hazardous waste management and Handling Rules – Characterization of hazardous wastes – Analytical methods –Hazardous waste inventory- Source reduction of hazardous wastes Hazardous waste landfills-Site selections-design and operation-HW reduction, TSDF concept - Transboundary movement of wastes – Basal Convention Hazardous waste treatment technologies-Physical, chemical and thermal treatment of hazardous waste-Solidification, Chemical fixation-Encapsulation-Pyrolysis and Incineration-, - Recycling and reuse-Hazardous Site remediation – onsite and offsite Techniques.

Unit 2

Biomedical waste- Definition- Regulatory aspects of Biomedical Waste. Sources-Classification-Waste Handling and Collection-Segregation and labeling- Treatment – autoclaving, Incineration, Chemical Disinfection –disposal. Infection control Practices. Regulatory aspects

E Waste-Waste management, Waste characteristics- Generation– Collection -Material Composition-Transport-Treatment and disposal. Recycling and Recovery – intergraded e-waste management

Unit 3

Hazardous waste landfills – Site selections – landfill design and operation – Regulatory aspects – Liner System- Cover system- Leachate Collection and Management – Environmental Monitoring System- Landfill Closure and post-closure care

Textbook(s)

1. Basic Hazardous waste management, William C. Blackman.Jr, Third Edition, 2001, Lewis Publishers
2. Hazardous waste management Charles A. Wentz. Second edition 1995. McGraw Hill International.
3. Environmental Sciences by Daniel B. Botkin and Edward A. Keller, Wiley student, 6th edition- 2009.
4. Harry M. Freeman, Standard handbook of Hazardous waste treatment and disposal McGraw Hill 1997.

Reference(s)

1. Integrated solid waste management George Techobanoglous, Hilary Theisen and Sammuel A.Vigil.
2. Standard handbook of Hazardous waste treatment and disposal by Harry M. Freeman, McGraw Hill 1997.
3. Hazardous Waste (Management and Transboundary Movement) Rules, Ministry of Environment and Forests, Government of India, New Delhi, 1989
4. Biomedical Waste (Management and Handling) Rules, Ministry of Environment and Forests, Government of India, New Delhi, 1998
5. Electronic Waste Management and Handling Rules, Ministry of Environment and Forests, Government of India, New Delhi, 2011
6. Guidelines and criteria for hazardous waste landfills and hazardous waste treatment disposal facilities, Central Pollution Control Board, New Delhi, 2010

23CHE347 INDUSTRIAL STATISTICS FOR CHEMICAL ENGINEERS L-T-P-C: 3-0-0-3

Pre-Requisites: None

Course Objectives

- Introduce undergraduate students to the *application* of principles of probability and statistics and in chemical engineering industrial contexts.
- Build proficiency in students to apply the concepts of random variables, distributions, sampling, parameter estimation and hypothesis testing to engineering problems.
- Familiarize students on the use of software tools for data visualization and statistical analysis.

Course Outcomes

After this course, students will be able to

CO1	Demonstrate understanding of principles of process data analysis and data sampling.
CO2	Demonstrate understanding of probability, random variables, population and sample distributions, and limit theorems and solve relevant engineering problems.
CO3	Estimate population parameters and confidence intervals from random samples in engineering contexts.
CO4	Formulate and test statistical hypotheses in engineering applications.
	Use software tools for data visualization and statistical analysis in chemical engineering applications.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1		3	1												
CO2		3	3	1											
CO3		3	3	1											
CO4		3	3	1											
CO5		3	3	2	3								1	1	

Syllabus

Unit 1

Nature of Process Data and its Collection; Objectives of Process Data Analysis; Numerical versus Graphical Methods of Analysis; Sampling Data – Data Types, Errors; Acceptance Sampling and its Relevance in Plant Troubleshooting; Descriptive and Inferential Statistics

Random Events and Probability – Sample Spaces, Events and Probability; Counting, Conditional Probability, Independence, Bayes' Theorem; Random Variables – Discrete & Continuous Random Variables and their Distributions, Expectation, Variance and Standard Deviation, Skewness, Kurtosis; Special Distribution Functions – Binomial, Poisson, Geometric, Normal, Uniform, Exponential, Weibull, Two-Parameter Gamma

Unit 2

Joint Probability Distributions – Marginal and Conditional Distributions; Covariance and Correlation; Limit Theorems – Chebyshev's Theorem, Central Limit Theorem

Random Sampling and Sampling Distributions – Mean and Variance of Samples versus Populations; Chi-square, Student *t*, and *F* Distributions; Large Sample Approximations

Parameter Estimation – Method of Maximum Likelihood for Point Estimation; Confidence Intervals and Level of Confidence

Unit 3

Hypothesis Testing – Statistical Hypothesis, Method for Hypothesis Testing; Single Mean and Two Mean Tests using *Z* and *t* distributions; Single Variance using Chi-Square; Two Variance using *F*

Applications Involving Chemical Engineering Processes; Use of Software Tools such as Excel, MATLAB and R for Data Visualization and Statistical Analysis

Textbook(s)

1. K. M. Ramachandran, C. P. Tsokos, "Mathematical Statistics with Applications", Elsevier, 2009.
2. S. M. Ross, "Introduction to Probability and Statistics for Engineers and Scientists", Fifth Edition, Elsevier, 2014.
3. J. Ravichandran, "Probability and Statistics for Engineers", Wiley India, 2010.

Reference(s)

1. Douglas C. Montgomery and George C. Runger, "Applied Statistics and Probability for Engineers", Third Edition, John Wiley, 2008.
2. F. M. Dekking, C. Kraaikamp, H. P. Lopuhaä, L. E. Meester, "A Modern Introduction to Probability and Statistics: Understanding Why and How", Springer, 2005.

23CHE348 INDUSTRY 4.0 FOR PROCESS INDUSTRIES L-T-P-C: 3-0-0-3

Pre-Requisites: None

Course Objectives

This course introduces undergraduate engineering students to the principles of data-driven instrumentation, communication, and distributed control in process industries, as part of Industry 4.0. Specific objectives include:

- Introduce students to industrial documentation, standards, regulations, and components of Industry 4.0.
- Facilitate understanding of online measurements of process parameters, communication, and actuation in real-time.
- Introduce undergraduate engineering students to distributed control systems, their architectures, hardware, and software.
- Introduce through case studies how data-driven instrumentation, communication, and control are used in chemical process industries, including in aspects of safety, hazard management, and reliability.

Course Outcomes

After this course, students will be able to

CO1	Demonstrate understanding of industrial documentation and components of Industry 4.0.
CO2	Demonstrate understanding of the principles and design of inline instrumentation for process parameter measurements, and inline actuators.
CO3	Demonstrate understanding of the principles of IoT-based communication, and its features.
CO4	Demonstrate understanding of the architectures, and hardware and software components of distributed control systems.
CO5	Demonstrate understanding of the use of distributed control systems in chemical process industries, including for safety, hazard management, and reliability.

CO-PO-PSO Mapping: [affinity[#]: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	3	1	2	2									2		
CO2	3	1	2	2									2		
CO3	3	1	2	2											
CO4	3	1	2	2											
CO5	3	1	2	2			2						2		

Syllabus

Unit 1

Industrial Documentation – Process Flow Diagram, Piping and Instrumentation Diagrams, Standards and Regulations; Components of Industry 4.0 – Process Instrumentation and Transmitters, Communication, Programmable Logic Controllers (PLC), Actuators and Valves – Architecture and Programming Languages

Data-Driven Instrumentation – Measurement Uncertainty; Process Transmitters – Pressure and Differential Pressure, Level, Hydraulic Head, Fluid Flow, Weight, Temperature, pH, Chromatography; Sample Point Selection, Instrument Selection, Sample Conditioning

Unit 2

Actuators and Control Valves – Valve Types, Valve Sizing, Actuators, Accessories; IoT Communication – Messages, Local Area Networks, Token Systems, Protocols, Network Access, Transmission, Telemetry

PLC and Fieldbus – Hardware Architecture, Software and Memory Architecture, Inputs and Outputs (I/O), Programming

Distributed Control Systems – I/O Processing, Control Network and Modules, Human-Machine Interface; Supervisory Control and Data Acquisition (SCADA), Computer-Integrated Manufacturing, Open Systems – Networks and Architectures

Unit 3

Applications to Chemical Process Plants – Evaporators, Heat Exchangers, Boilers, Neutralization, Distillation, Reactors, Batch Processes (Selected Case Studies)

HAZOP Studies, Safety and Hazard Assessment, Protection Layers in Plant Operations, Reliability and Repairability Assessment

Textbook(s)

1. N. P. Sands, I. Verhappen (editors), “A Guide to the Automation Body of Knowledge”, Third Edition, ISA, 2018.
2. J. Love, “Process Automation Handbook: A Guide to Theory and Practice”, Springer, 2007.

Reference(s)

1. J. Stenerson, “Industrial Automation and Process Control”, Prentice Hall, 2003.
2. M. Asadnia, A. Razmjou, A. Beheshti (editors), “Artificial Intelligence and Data Science in Environmental Sensing”, Academic Press, 2022.
3. J. Park, S. Mackay, “Practical Data Acquisition for Instrumentation and Control Systems”, Elsevier, 2003.
4. P. Gründler, “Chemical Sensors”, Springer 2008.

23CHE349 INTERFACIAL SCIENCE AND ENGINEERING L-T-P-C: 3-0-0-3

Course Objectives:

To learn the surface and interfacial phenomena relevant to the thin film coatings, solid surfaces and colloids for better processing of different industrial products, intermediates and raw materials.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Understand the fundamental theories associated with the surface and interface properties.
CO2:	Recognize the surface and interfacial phenomena of thin film coatings and colloids.
CO3:	Analyze the role of surface and interface properties in the processing of different industrial products, intermediates, and raw materials.
CO4:	Design of new product formulations with superior surface and interface properties.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	1	1	2		2						2	1	
CO2	3	2	1	1	2		2						2	1	
CO3	3	3	1	1	1		1						3	2	
CO4	3	2	3	2	1		1						1	3	

Syllabus

Unit 1

Introduction –colloids, surfaces and interfaces, Colloids-classifications and characterizations, Colloids-preparation and purification methods - Surfaces and interfaces –definitions, description of different surface and interfaces, applications of interfacial engineering, - Surface, interfacial tensions and measurement of interfacial tension using different methods, - Surface properties

Attractive forces and van der Waals interactions - Coulombic forces and ionic, dipole interactions Van der Waals forces in polar and nonpolar media - Electrostatic and Electrokinetic theories Source of interfacial formation and electrical double layer (EDL) - *Helmholtz model*, *Gouy-Chapman* model, *Debye–Hückel theory* on EDL, EDL thickness - Surface potential, Zeta potential, pH effects, calculations - Electroosmosis and Electrophoresis, types, applications

Unit 2

Capillary theories, Capillary driving forces in liquid–fluid systems, Solid–Liquid–Fluid Systems: The Effect of Contact Angle - Capillary Flow and Spreading Processes, coefficients, petroleum recovery, measurement of capillary driving forces -Surface tension gradients, marangoni flow, contact angle hysteresis, dynamic contact angles, Practical capillary systems – wetting in fibers, water proofing, wicking process and detergency,
Adsorption – Gibbs surface excess, adsorption equation for Solid-Fluid interfaces, Gibbs adsorption isotherm-Physisorption Vs Chemisorption, Thermodynamic considerations, heterogeneous catalysis

Catalytic poisons, promoters and adsorption isotherms at S-V interfaces, Langmuir, Freundlich, BET adsorption isotherms and surface area calculations, adsorption at S-L interfaces- Adsorption isotherms in solid–liquid systems, nature of the adsorbent surface, environmental effects- Colloidal stability – Coagulation, flocculation, mechanism for colloidal formation

Unit 3

Colloidal behavior, Lennard–Jones 6–12 potential, attractive forces, sources of colloidal stability, critical coagulation concentration-Coagulation kinetics- fast and slow, Smoluchowski equation, DLVO theory, reversible flocculation

Emulsions-formation, emulsification methods-Emulsifiers and Stabilizing agents, types, functions HLB number, PIT and Application of HLB and PIT in Emulsion Formulation-Association colloids-vesicles, micelles and membranes-Surfactant solubility, krafft temperature, and cloud point -Surfactant liquid crystals, micelles, micelle formation - Critical micelle concentrations (CMC)-factors affecting CMC, additives - Vesicles and bilayer membranes –definitions, applications

Optical properties-Light scattering, turbidity, light scattering theories -Scattering by small particles, large particles, Rayleigh, Debye and Mie scattering of particles - Foams, Aerosols, Foam stability and microfoams -Rheological properties of colloidal dispersions- viscosity, newtonian and non-newtonian fluids, Electroviscous effects

Textbook(s) / Reference(s)

1. Drew Myers, “Surfaces, Interfaces, and Colloids: Principles and Applications.” 2nd Edition, Wiley-VCH, 1999
2. A.W. Adamson and A.P. Gast, “Physical Chemistry of Surfaces,” 6th Edition, Wiley-Interscience, 1997.
3. P.C. Hiemenz and R. Rajagopalan, “Principles of Colloid and Surface Chemistry,” 3rd Edition,, Academic Press, New York, 1997.
4. J.N. Israelachvili, “Intermolecular and Surface Forces,” 2nd Edition, Academic Press, New York, 1992.

23CHE350 INTRODUCTION TO DATA-DRIVEN MODELING IN CHEMICAL ENGINEERING
L-T-P-C: 2-0-3-3

Pre-Requisites: Introduction to Chemical Engineering, Probability and Statistics for Chemical Engineers

Course Objectives

Building on the course Probability and Statistics for Chemical Engineers, the course Introduction to Data-Driven Modeling in Chemical Engineering introduces students to data-driven models such as regression, design of experiments and related data analysis. The objectives of the course are
•Build proficiency in using regression-based models for chemical engineering applications
•Familiarize students with ANOVA and hypothesis testing.
•Build proficiency in statistical design of experiments and process optimization for chemical engineering applications
•Familiarize students on the use of software tools for Regression, Design of Experiments and ANOVA (JMP, R, Minitab, MATLAB)

Course Outcomes

After this course, students will be able to

CO1	Demonstrate understanding and application of regression-based models in chemical engineering applications.
CO2	Demonstrate understanding and application of ANOVA in chemical engineering applications
CO3	Demonstrate understanding and application of statistical design of experiments and process optimization in chemical engineering applications.
CO4	Use software tools for Regression, Design of Experiments and ANOVA in chemical engineering applications.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	2	3	3	2									1	1	1
CO2	2	3	3	2									1	1	1
CO3	2	3	3	2			1						1	1	2
CO4	2	3	3	2	3		1						1	1	2

Syllabus

Unit 1
Introduction to Modeling - Data-Driven, Conceptual and Physics-based Models; Data-Driven Models for Chemical Engineering Systems – Examples; Types of Data-Driven Models – Statistical vs. Artificial Intelligence, Predictive vs. Descriptive; Model Selection; General Approach to Data-Driven Models
Regression-Based Models: Simple Linear Regression – Point and Interval Estimation, Method of Least Squares, Residuals, Sum of Square of Errors; Quality of Regression – Mean Square Error, Confidence Intervals of Coefficients, Correlation Coefficient R^2, R^2(adj), R^2(pred), Scatter Plots, Outliers and Leverage Points

Unit 2

Multiple Linear Regression; Transforming Nonlinear Models to Linear Regression Models – Exponential, Power Law, Polynomial Regression; Principal Component Analysis; Partial Least Squares; Applications to Chemical Engineering Problems – Thermodynamic and Transport Properties Prediction, Correlations, Rate Laws, Chemometrics

Analysis of Variance (ANOVA) – One-Way Analysis and Two-Factor Analysis; Hypothesis Testing

Unit 3

Statistical Design of Experiments – understanding the importance of exploratory and confirmatory analyses in R&D – and process optimization - factorial designs (creating factorial and fractional factorial designs, design structure, main effects, interactions, resolution & confounding, analysis), central composite and Box-Behnken designs and analysis; Response surface methodology; A very basic introduction to control charts; Chemical Engineering Applications

Use of Software for Regression, Design of Experiments and ANOVA

Textbook(s)

1. K.M. Ramachandran and Chris P. Tsokos, "Mathematical Statistics with Applications", Academic Press, 2009.
2. Douglas C. Montgomery and George C.Runger, "Applied Statistics and Probability for Engineers", Third Edition, John Wiley, 2008.
3. Douglas C. Montgomery, "Design and Analysis of Experiments", Fifth Edition, Wiley, 2000.

Reference(s)

1. S. M. Ross, "Introduction to Probability and Statistics for Engineers and Scientists", Fifth Edition, Elsevier, 2014.
2. G. E. P. Box, J. S. Hunter, W. G. Hunter, "Statistics for Experimenters: Design, Innovation, and Discovery", Wiley, 2005.

23CHE352 MACHINE LEARNING IN CHEMICAL ENGINEERING L-T-P-C: 3-0-0-3

Pre-Requisites: None

Course Objectives

This course aims to introduce the principles of machine learning to undergraduate chemical engineering students. Specific objectives include:

- Introduce data pre-processing approaches before data mining.
- Introduce basic principles underlying machine learning.
- Introduce regression, classification, and clustering ML algorithms.
- Introduce how ML is applied in chemical engineering problems through case studies.

Course Outcomes

After this course, students will be able to

CO1	Explain the use of data pre-processing tools for learning and apply software tools for pre-processing of data.
CO2	Demonstrate understanding of the principles and evaluation of machine learning.
CO3	Explain the algorithms underlying linear regression, their performance evaluation, and use machine learning tools for problem solving.
CO4	Explain the algorithms underlying supervised and unsupervised classification and clustering and use machine learning tools for problem solving.
CO5	Demonstrate how ML can enhance modeling and simulation of chemical engineering processes.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	1	3	2	3	3										
CO2	1	3	2	3	3										
CO3	1	3	2	3	3										
CO4	1	3	2	3	3										
CO5	3	3	2	3	3								1	3	

Syllabus

(Note: The course is taught at an introductory level, with more emphasis on the application of machine learning to solving chemical engineering problems.)

Unit 1

Data Pre-Processing – Sampling, Denoising, Recognizing Inconsistencies and Duplicates, Missing Data; Data Transformation – Smoothing, Aggregation, Normalization, Feature Construction, Data Reduction, Compression; Data Mining Frameworks; Data – Objects vs. Attributes; Use of Software Tools – MATLAB

Tutorials; Applications in Chemical Engineering Contexts – Introduction to Data Reconciliation with Mass and Energy Balances
Machine Learning – Classification versus Regression; Deep Learning vs. Machine Learning – Differences; Supervised, Unsupervised and Reinforcement Learning; Supervised Learning – Hypothesis, Ground Truth, Bias and Variance; Linear Regression in ML Environment – Univariate and Multivariate Regression; Regression Diagnostics – Goodness of Fit, Outliers, Homoscedasticity and Normality, Overfitting and Underfitting; Use of Software Tools – MATLAB Tutorials

Unit 2

Classification – Evaluating a Classification Model Performance: Confusion Matrix, ROC, Fitting Line, Regularization; Generalized Linear Models (GLM) for Classification; Process Flow for Supervised Learning; Model Selection and Optimization – Training, Validation, and Test Sets, Cross Validation, Selection Criteria: Error Rate, Loss and Utility Functions; Use of Software Tools – MATLAB Tutorials
Decision Trees – Greedy Algorithm, Graphical Representation, Test Attributes – Statistical Significance Test, Gini, and Entropy, Stopping Partitioning; Random Forest Classifier; Support Vector Machine; Principal Component Analysis; Use of Software Tools – MATLAB Tutorials

Unit 3

Unsupervised Learning – K-Means Clustering, K-Nearest Neighbor Clustering, Hierarchical Clustering; Dimensionality Reduction – Principal Component Analysis; Use of Software Tools – MATLAB Tutorials
Examples in Chemical Engineering – Prediction of Properties and Performance, Energy Consumption, Control and Sensing

Textbook(s)

1. S. Russell, P. Norvig, "Artificial Intelligence: A Modern Approach", Fourth Edition, Prentice Hall, 2010.
2. M. Swamynathan, "Mastering Machine Learning with Python in Six Steps", Apress, 2017.
3. S. Mukhopadhyay, "Advanced Data Analytics using Python", Apress, 2018.
4. J. Ren, W. Shen, Y. Man, L. Dong (editors), "Applications of Artificial Intelligence in Process Systems Engineering", Elsevier, 2021.

Reference(s)

1. C. C. Aggarwal, "Artificial Intelligence: A Textbook", Springer, 2021.
2. A. C. Müller, S. Guido, "Introduction to Machine Learning with Python: A Guide for Data Scientists", O'Reilly, 2016.
3. Recent articles on applications of AI and ML in Chemical Engineering (case studies)

23CHE353 MATERIAL CHARACTERIZATION L-T-P-C: 3-0-0-3

Course Objectives

To make students aware of various characterization techniques and to evaluate the material with suitable characterization techniques.

Course Outcomes

After the completion of this course, student will be able to

CO1:	Study the fundamental principles behind the individual characterization methods which are included in the curriculum.
CO2:	Investigate, interpret and present observations from the different characterization methods.
CO3:	Assess which methods of characterization are appropriate for different material / requirement/ condition/ problems.
CO4:	Predict the uncertainty of observations and results from the different characterization methods

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2					2					2	2	1	2
CO2	3	2					2					2	1	2	2
CO3	3	2					2					2	2	2	2
CO4	2	2	3		2							2	2	2	1
CO5															

Syllabus

Unit 1

Imaging microscopies and Image analysis: Optical microscopy, scanning probe microscopy, fluorescence microscope, X-ray microscopy, scanning electron microscopy and transmission electron microscopy, Image analysis, EDX.

Unit 2

X-ray -diffraction, properties of x-rays, review of crystal systems and miller indices, Laue conditions, braggs conditions, diffraction methods, phase identifications, electron diffraction methods. XRF, PES, XPS

Unit 3

Spectroscopy: type, principle, sample preparation, result interpretation: UV-Visible, FTIR, Raman, NMR, MS, fluorescence, atomic. Thermal and Thermomechanical analysis: differential scanning calorimetry and Differential thermal analysis. Thermogravimetric analysis, Dynamic mechanical analysis and TMA.

Textbook(s)

1. Yang Leng, "Materials Characterization: Introduction to Microscopic and Spectroscopic Methods", 2013, Wiley VCH; **ISBN-10:** 3527334637, **ISBN-13:** 978-3527334636.
2. KP. Menard, "Dynamic mechanical analysis: A practical introduction", CRC press, 1999

Reference(s)

1. BD Cullity and SR Stock, "Elements of X-ray diffraction", 3rd Edition, Prentice Hall 2001

23CHE354 MATERIAL PROCESSING L-T-P-C: 3-0-0-3

Pre-Requisite: None

Course Objectives

Course Outcomes

At the end of the course students would be able to:

CO1:	Explain the forming, shaping, and joining processes employed for metallic materials
CO2:	Explain the various processes for the manufacture of ceramic products
CO3:	Classify and explain different polymerization processes; Comprehend various plastics conversion techniques
C**O4:**	Enumerate the various approaches for nanomaterials synthesis .

Syllabus

Unit 1

Metals and Alloys: Metal casting; forming and shaping processes: rolling, forging, extrusion, drawing, sheet, and metal forming; joining processes: welding, machining; Powder metallurgy: pressing and sintering; Drilling, milling, cutting; grinding. Ceramics: Glass working; Processing of traditional, new ceramics and cermets; powder pressing, tape casting

Unit 2

Polymers : Polymerisation: Condensation, Addition, Bulk, Solution, Suspension, Emulsion; Polymer Processing: Mixing, extrusion, moulding, spinning, casting, calendaring, joining, foam processing, rubber processing, and machining of plastics, processing of polymer matrix composites, solvent cementing, adhesive bonding.

Unit 3

Nanomaterials : Top-down and bottom-up approach; optical and E-beam lithography, MBE, etching, vacuum processing/PVD and CVD; molecular self-assembly; nanoparticle synthesis – sol gel, solid phase, solvothermal and co-precipitation processes

Textbook(s) / Reference(s):

1. S. Kalpakjian and S. R. Schmid, "Manufacturing Engineering and Technology", Fourth Edition, Pearson Education India, 2002.
2. M. P. Groover, "Principles of Modern Manufacturing", Fifth Edition, SI Version, Wiley India, 2014.
3. M. D. Ventra, S. Evoy and J. R. Heflin, "Introduction to Nanoscale Science and Technology", Kluwer Academic Publishers, 2004.
4. Chanda and S. K. Roy, "Plastics Technology Handbook", CRC Press, Atlanta, 2007.
5. A. Ghosh and A.K. Mallik, "Manufacturing Science", Affiliated East-West Press Pvt. Ltd., 2010.

23CHE355 MATERIALS SELECTION AND DESIGN L-T-P-C: 3-0-0-3

Pre-Requisite: Materials Technology

Course Objectives

Course Outcomes

At the end of the course students would be able to:

CO1:	Explain the forming, shaping, and joining processes employed for metallic materials
CO2:	Explain the various processes for the manufacture of ceramic products
CO3:	Classify and explain different polymerization processes; Comprehend various plastics conversion techniques
C**O4:**	Enumerate the various approaches for nanomaterials synthesis .

Syllabus

Unit 1

Structure-Property-Function Relationships in Materials, Process-Property Interaction, Material Property Charts, Design through Materials Synthesis and Modification, Materials and Process Information for Design; Translation, Screening and Ranking of Materials, Manipulating Properties - Density, Mechanical, Thermal, Electrical, Magnetic, Optical, Reactivity, and Catalytic Properties

Unit 2

Selected Case Studies: Ball Milling, Sintering, Layered Compounds, Chemical Vapor Deposition of Solids, Crystal Growth, Hydrothermal Synthesis, Sol-Gel Process, Polymer Synthesis, Gas-Phase Pyrolysis for Liquids, Catalytic Control of Fischer-Tropsch Process for Engine-Grade Fuels,

Unit 3

Nanomaterials: Nanoparticles, Soft Templating, Self-Assembled Monolayers, Hard Templating - Nanocasting, Nanowires using Templated Deposition, Chemical Synthesis of Graphene, Graphene Functionalization for Applications, Biomaterials: Designing Bone Scaffolds, Contact Lenses

Textbook(s) / Reference(s):

1. M. Ashby, H. Shercliff and D. Cebon, "Materials: Engineering, Science, Processing and Design", Second Edition, Butterworth-Heinemann, 2010
2. U. Schubert and N. Hüsing, "Synthesis of Inorganic Materials", Third Edition, Wiley-VCH, 2012
3. Selected recent papers published in reputed international journals discussing materials design - for case studies

23CHE356 NANOSCIENCE AND NANOTECHNOLOGY L-T-P-C: 3-0-0-3

Course Objectives:

To learn fundamentals dealing with the processing, characterization of nanomaterials and nanoensembles for fabricating various electronic devices and for biological applications at the nanoscale levels.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Understand the length scale concepts, atomic structures, top-down and bottom-up preparation methods of various nanostructures
CO2:	Use the principles of processing and characterization methods of various nano-ensembles and nanoscale devices
CO3:	Engage the electron and scanning probe microscopes to characterize or to manipulate different nanostructures and nanodevices
CO4:	Design and construct nano-electromechanical devices (NEMS), nanofluidic channels and optoelectronic devices using various nanostructured materials.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1	3								2	2	
CO2	2	1	3	1	3								2	2	
CO3	2	2	2	2	3								3	3	2
CO4	3	3	3	3	3								3	3	2
CO5															

Syllabus

Unit 1

Nanotechnology Fundamentals- Atomic structure, molecules and phases, microstructure and defects in nanocrystalline materials- top-down and bottom up approach, nanostructure preparation techniques - overview Micro/nano fabrication methods: Top-down approach – nanolithography techniques – dip pen, projection optical, e-beam, focused ion beam, Extreme UV, proximity x-ray, nanoimprinting, microcontact printing.

Unit 2

Bottom-up approach: Molecular recognition, Self-assemblies – hydrogen bonded, biomimetic and dimensional nanoparticle arrays, self assembled monolayers, electrostatic self-assembly, sol-gel process, vapor depositions (CVD, PVD, MBE, ALD) and sputtering techniques - Molecular switches –monomolecular in solutions, on surfaces (electron, pH and light driven switches)
Microscopy - Optical, scanning electron and transmission electron microscopes - Scanning probe microscopes - AFM, STM and coupled devices for atomic manipulations. Surface characterization techniques- XPS, UPS and Emission spectroscopy

Unit 3

Photonic crystals by microfabrication- photonic crystals by self-assembly - photonic crystals with tunable properties - Quantum-confined optoelectronic systems - size, energy level and shape engineering of quantum dots- single quantum dot devices- Nanoelectromechanical systems- surface machining and characterization of NEMS -Dynamics of NEMS-Integration of NEMS with quantum electronic devices

Nanofluidics-fluids at the micro-and nanometer scale-fabrication of nanoporous and nanofluidic devices - Applications of nanofluidics- Nano-bio technology (lipid and lipid templates, self assembled monolayers, biological computing, protein engineering, biosensors, drug delivery, PDT)

Textbook(s)

1. Massimiliano Di Ventra, Stephane Evoy and James R. Heflin, Jr*, "Introduction to Nanoscale Science and Technology"* Kluwer Academic Publishers, 2004.
2. T. Pradeep, "*Nano: The Essentials/ Understanding Nanoscience and Nanotechnology*,"Tata Mcgraw-Hill Publishing Company Limited, 2007.
3. Cristian Contescu, Karol Putyera, *"Dekker Encyclopaedia of Nanoscience and Nanotechnology,"* 2nd Edition, CRC Press Publications, 2009, ISBN 9780849396397 (six volume set).

23CHE357 OPTIMIZATION TECHNIQUES IN CHEMICAL ENGINEERING L-T-P-C: 3-0-0-3

Pre-Requisites: None

Course Objectives

- Introduce undergraduate chemical engineering students to optimization techniques and their applications.
- Introduce the mathematical representations, techniques, and solution approaches for constrained and unconstrained, linear and nonlinear functions.
- Familiarize students on the use of software tools for optimization.
- Demonstrate applications of optimization in chemical engineering process design and operation.

Course Outcomes

After this course, students will be able to

CO1	Demonstrate understanding of principles, conditions, models, and basic concepts of optimization.
CO2	Formulate and solve single- and multi-variable unconstrained optimization problems, including chemical engineering applications.
CO3	Formulate and solve Linear Programming problems using Simplex Method, including chemical engineering applications.
CO4	Formulate and solve simple Quadratic Programming problems, including chemical engineering applications.
CO5	Solve chemical engineering optimization problems using software tools.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO		3	1												
CO2	2	3	3	2									1	3	
CO3	2	3	3	2									1	3	
CO4	2	3	3	2									1	3	
CO5	3	3	3	3	3		1		1	1			3	3	2

Syllabus

Unit 1

Introduction to Optimization Problems – Degree of Freedom Analysis, Necessary and Sufficient Conditions; Models for Optimization – Review; Formulation of Objective Functions; Basic Concepts – Continuity, NLP, Convexity, Quadratic Approximation, Extrema

Optimization of Single-Variable Unconstrained Functions: Scanning and Bracketing, Newton and Quasi-Newton Methods; Least Square Problems: Levenberg-Marquardt Method; Chemical Engineering Applications

Unit 2

Unconstrained Multivariable Optimization: Direct Search, Gradient-Based Methods; Necessary and Sufficient Conditions for Constrained and Unconstrained Optimum: Wolfe Conditions; Chemical Engineering Applications

Linear Programming: Introduction, Simplex Method

Unit 3

Introduction to Nonlinear Programming: Necessary Conditions for Local Extremum, Quadratic Programming – Equality Constraints only; Software Tools for Optimization. Applications in Chemical Engineering: Heat Transfer and Energy Conservation, Separation Processes, Reactor Design, Process Control

Textbook(s)

1. T. F. Edgar, D. M. Himmelblau, "Optimization of Chemical Processes", McGraw-Hill International Edition, 1989.
2. L. T. Biegler, "Nonlinear Programming: Concepts, Algorithms and Applications to Chemical Processes", MOS-SIAM Series on Optimization, 2010.

Reference(s)

1. J. Nocedal, S. J. Wright, "Numerical Optimization", Springer, 1999.
2. G. V. Reklaitis, A. Ravindran, K. M. Ragsdell, "Engineering Optimization: Methods and Applications", John Wiley and Sons, 1983

23CHE358 PETROLEUM REFINING AND PETROCHEMICAL TECHNOLOGY L-T-P-C: 3-0-0-3

Pre-Requisites: Chemical Technology, Process Heat Transfer, Mass Transfer Operations I, Mass Transfer Operations II

Course Objectives

To understand the design, operations and flow sheet of modern petroleum refinery and various petrochemicals unit.

Course Outcomes

After the completion of this course, student will be able to

CO1:	Understand the concepts of various physical and chemical processes in modern refinery
CO2:	Ability to understand the overview and block diagrams of various operations involved in fractionation of crude oil
CO3:	Analyze the design, operations and flow sheet of various units in fractionation of crude oil
CO4:	Develop and analyze the flow sheets of various petrochemicals processes

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2						2				3		
CO2	3	2	2						2				3		
CO3	3	2	2	2		1	1		2				3	2	
CO4	3	2	2			1	1		2				3	2	

Syllabus

Unit 1

Petroleum refining: Crude oil distillation process – thermal conversion processes. Conventional thermal cracking – vis-breaking and design variables of vis-breaking – coking: Fluid coking, flexi coking, delayed coking and hardware considerations – catalytic conversion processes-fluid catalytic cracking with special reference to catalyst and reactor design configurations – hydro-treating, hydrodesulphurization and hydro-cracking – Reforming: process, catalyst, reactor design configuration – alkylation – isomerization – lube oil manufacturing process, solvent – de-asphalting, solvent de-waxing and hydro finishing – production of PET, waxes and bitumen.

Unit 2

Petrochemical technology: Petrochemical industry overview, primary raw materials for petrochemicals, first generation petrochemicals – hydrocarbon intermediates and their production, non-hydrocarbon intermediates, olefin production, processing of olefins C_4& C_5 cut from steam cracking and fluid cracking.

Unit 3

Aromatics production, second generation petrochemicals from: methane and synthesis gas derivatives, ethylene and ethylene derivatives, propylene and propylene derivatives, C4 and C5 derivatives, aromatics – benzene, toluene and xylene derivatives – third generation petrochemicals – polymers, elastomers, polyurethanes and synthetic fiber.

Texbook(s)

1. Ram Prasad, "Petroleum Refining Technology", Khanna Publishers, Delhi, 2000.
2. J.H. Gary, G.H. Handwerk and M.J.Kaiser, "Petroleum Refining Technology and Economics", 5th Edition, CRC Press, New York, 2007.
3. G.D. Hobson and W. Pohl, "Modern Petroleum Technology", 6th Edition, Wiley, New York, 2000.
4. B.K. BhaskaraRao, "A Text on Petrochemicals", Khanna Publishers, New Delhi, 2008.

Reference(s)

1. R.A. Meyers, "Handbook of Petroleum Refining Processes", 2nd Edition, McGraw Hill, New York, 1996.
2. J.A. Moulijin, M. Makkee and A. Van Diepen, "Chemical Process Technology", Wiley, New York, 2001.
3. I.D. Mall, "Petrochemical Process Technology", Macmillan India Ltd, New Delhi, 2007.
4. Sami Matar and Lewis F Hatch, "Chemistry of Petrochemical Processes", Gulf Publishing Company, Houston, Texas, 2000.

23CHE359 PHARMACEUTICAL TECHNOLOGY L-T-P-C: 3-0-0-3

Course Objectives:

The objective of this course is to understand basic concepts of drug delivery systems and its manufacturing processes in the field of Pharmaceutical Technology

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Well aware with all the drug delivery systems, dosage forms and regulatory policies of the pharma industry.
CO2:	Learn about the formulations, drug metabolism and pharmacokinetic action of drugs on the body.
CO3:	Study the manufacturing principles of different dosage forms
CO4:	Learn the pharmaceutical product and their control

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO2	PSO3
CO1	1							2							
CO2	2	2				1							2	2	
CO3	2	2				1							2	2	
CO4	2	2				1							2	2	

Syllabus

Unit 1

Introduction to drugs, pharmacy, drug dosage forms, and drug delivery systems, New drug development and approval process, Current good manufacturing practices, Intellectual property considerations, Drug formulation, metabolism and pharmacokinetic considerations.

Unit 2

Important unit processes and their applications: Bulk drug manufacturers, Type of reactions in bulk drug manufacture and processes. Special requirement for bulk drug manufacture. Manufacturing principles: wet granulation-dry granulation or slugging-direct compression-tablet presses, coating of tablets, capsules, sustained action dosage forms-parental solution-oral liquids-injections-ointment-topical applications, Preservation, analytical methods and test for various drug and pharmaceuticals, packing-packing techniques.

Unit 3

Pharmaceutical product and their control: Therapeutic categories such as vitamins, laxatives, analgesics, non-steroidal contraceptives, Antibiotics, biologicals, hormones ; Advanced drug delivery systems.

Textbook(s)

1. L.V. Allen, N.G. Popovich, and H.C. Ansel, "Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems", 9^{th} Edition, Lippincott Williams and Wilkins, 2010.
2. K.E. Avis, L, Lachman, and H. Lieberman, "Pharmaceutical Dosage Forms: Parentral Medication"s, 2^{nd} Edition, Informa Healthcare, 1993.

Reference(s)

1. L. Lachman, "The Theory and Practice of Industrial Pharmacy", CBS Publishers & Distributors Pvt. Ltd., 2009.
2. S.K. Niazi, "Handbook of Preformulation: Chemical, Biological, and Botanical Drugs", Informa Healthcare, 2006.
3. Remington's Pharmaceutical Science, Mark Publishing and Co

23CHE360 **POLYMER MATERIALS** **L-T-P-C: 3-0-0-3**

Pre-Requisites

Course Objectives:

It is intended to give students an understanding of the relationship between structure, properties, and applications of different polymers in order to equip them with the ability to predict properties based on structure, whereby they will be able to substitute a cost-effective and high-performing polymer for particular applications.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Predict the main properties of a polymer from its chemical structure.
CO2:	Seek information in terms of the type, mechanism and technique of polymerization used for different types of polymers.
CO3:	Observe the effect of rheology on polymer properties and the types of processing techniques used for polymers.
CO4:	Calculate the cost of plastic products with appropriate design, incorporating nontoxic, lifecycle and environmentally friendly aspects.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	-	2	2	2	-	-	-	-	2	2	0	1
CO2	3	2	2	-	2	-	2	-	-	-	-	2	-	2	2
CO3	3	3	2	-	2	2	3	-	-	-	-	2	3	0	2
CO4	3	3	3	2	2	-	-	-	3	-	-	2	0	2	2

Syllabus

Unit 1

Structure of polymers- thermoplastic, thermoset, rubber – linear, branched, crosslinked,and network polymers, polymerization types- addition, condensation, mechanism, methods – bulk, solution, suspension and emulsion, crystalline – amorphous, orientation – orientation – molecular weight – intermolecular force, solubility parameter, Tg and Tm.

Unit 2

Manufacturing, mechanical, thermal, electrical and chemical properties and application of commodity plastics- PE, PP, PVC, PS ; Engineering plastics –ABS, PC, PMMA, polyamide, polyacetal, PET, PBT, PTFE. High performance plastics – PES, PEI, PEEK, conducting polymer.

Unit 3

Thermoset materials – PF, UF, MF, epoxy and unsaturated polyester resin, Rubber – natural rubber, synthetic rubber- PB, SBR, nitrile, chloroprene, butyl, silicone, compounding and additives.

Textbook(s)

1. J. A. Brydson, "Plastics Materials" Butterworth- Heinemann – Oxford, 7th Edition,, London, 1999
2. Maurice Morton, "Rubber Technology", 3rd Ed, Kluwer Academic Pub, Dordrecht, Netherlands, 1999
3. Manas Chanda and Salil K. Roy, "Plastics Technology Handbook", CRC Press, Atlanta, 2007

Reference(s)

1. *D.W. Van Krevelenand P.J. Hoftyzer, "Properties of Polymer", 3rd Edition Elsevier Scientific Publishing Company Amsterdam – Oxford – New York. 1990.*
2. *Jozef Bicerano, "Prediction of Polymer Properties", Second Edition, Marcel Dekker Inc.New York, 1995.*

23CHE361 POLYMER PROCESSING L-T-P-C: 3-0-0-3

Course Objectives:

To objective of this course is to develop fundamental knowledge in the area of polymer processes with emphasis on the basic principles of all shaping operations used in polymer processing industry.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Elucidate the physical basis of polymer processing like flow behaviour and mixing of additives
CO2:	Comprehend the theoretical basis of injection moulding and extrusion and their offshoot processes.
CO3:	Explicate a wide range of operations like compression and transfer moulding, rotational moulding, blow moulding, thermoforming and composites processing.
CO4:	Select appropriate processing methods for the conversion of polymer feed to products.

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1			1								2		1
CO2	2	3			2							3	3		3
CO3	2	3			2							3	3		3
CO4	1	3			3							3	3		3

Syllabus

Unit 1

Physical Basis of Polymer Processing-Mixing-distributive and dispersive mixing equipment. Extrusion-Features of a Single Screw Extruder, Analysis of Flow, Aspects of Screw Design, Operating Point. Twin Screw Extrusion-Processes – Pipe, Profile, Blown Film, Wire and Cable coating, Fibre, Film and sheet extrusion, Co extrusion-Melt Fracture-Sharkskin-Die swell.

Unit 2

Injection Moulding-Principles- Moulding Cycle- Reciprocating Screw injection Moulding Machine-Types of Clamping Units-PVT diagram-Aspects of Product Quality-Hot Runner Moulding-Gas Assisted Injection Moulding. Blow Moulding-Principles- Injection Blow Moulding – Extrusion Blow Moulding – Stretch Blow Moulding - Troubleshooting – Thermoforming-Vacuum Forming-Pressure Forming-Material Stress and Orientation-Applications in Packaging.

Unit 3

Compression and Transfer Moulding - Types of Moulding Machines-Transfer Moulding-Trouble shooting – Comparison. Polymers in Rubbery State- Calendaring process-Types of Calendars, Roll Deflection and

Cambering-Rotational Moulding-Types of machines, Moulds, Materials. Fiber Reinforced Plastics-Materials-Lay up processes-SMC, DMC-Resin Transfer Moulding-Pultrusion, Bag Moulding Processes-Filament Winding. 3D printing- Equipment and Materials used. Joining and machining of Plastics-Welding of Plastics-Ultrasonic, Induction, Hotplate, High Frequency. Solvent Cementing-Adhesive Bonding.

Textbook(s)

1. B. Strong, "Plastics: Materials and Processing", Prentice Hall ,2012.
2. D.H. Morton-Jones," Polymer Processing", Chapman & Hall, 1989.

Reference(s)

1. C.A. Harper (Ed), "Handbook of Plastic Processes", John and Wiley 2006.
2. M.L.Berins (ed.), "Plastics Engineering Handbook Of The Society Of The Plastics Industry", Springer, 2012.

23CHE362 PROCESS INTENSIFICATION L-T-P-C: 3-0-0-3

Pre-Requisite(s): Mass Transfer Operations I & II, Chemical Reaction Engineering

Course Objectives

The students will understand basics of process intensification and its application to chemical engineering, to reduce the cost of operation by improving the rates of heat transfer, mass transfer, reactions and separations and how to overcome equilibrium limitations, therefore the reactions can be conducted in kinetically controlled regimes.

Course Outcomes

After the completion of this course, student will be able to

CO1:	Identify inefficiencies, and economic pressures and environmental impacts of a process or operation
CO2:	Explain the principles behind process intensification
CO3:	Assess the developmental stage or a process of an intensified technologies based on evaluation of scientific and engineering literature (e.g. journals and patents), and industrial benchmarking.
CO4:	Choose a specific process from available technologies that can intensify reaction kinetics, separations and/or transport phenomena, or reduce processing cost.
CO5:	Evaluate different process options based on qualitative and quantitative measures to arrive at an optimal process design choice

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2				2						2	3		3
CO2	3												3		3
CO3	3	3	3	3	3							2	3	3	3
CO4	3	2	3	3		2							3	3	3
CO5	3	3	3	3	3	3	2				2		3	3	3

Syllabus

Unit 1

Electrically Enhanced Processes; Microfluidics: Electrokinetics, Magnetohydrodynamics, Opto-microfluidics; Pressure-based Enhancement;
Compact Heat Exchangers: Plate Heat Exchanger, Printed-Circuit Heat Exchanger, Spiral Heat Exchanger, Chart-Flo Heat Exchanger, Polymer-Film Heat Exchanger, Foam Heat Exchanger, Mesh Heat Exchanger; Micro-heat exchangers: Small Channels and Designs; Significance of dimensionless numbers

Unit 2

Intensified Reactors: Spinning Disk Reactors; Oscillatory Baffled Reactors; Taylor-Couette Flow Reactor Microreactors: Basics & Applications; HEX Reactors; Induction Heating, Sonochemistry, Microwave Enhancement, Plasma Enhancement, Laser-Induced Reactions; Choice of reactors based on reaction type; Operating regimes of reactors - Dimensionless Analysis
Supercritical Operation; Intensified Separation: Distillation Columns – Divided Wall Columns, Compact Heat Exchangers; HiGee; Centrifuges; Membrane-based Separation (Should we have this? – If so we can actually add these as a separate intensified separation units); Intensified Mixing: In-line Mixers: Static Mixer, Mixing on a Spinning Disk, Induction-Heated Mixer;

Unit 3
Reactive Separations: Reactive Distillation and Reactive Extraction; Membrane Reactors - Applications to dehydrogenation; Steam-methane reformation;
Case studies: Reaction separation of Plastic/Biomass pyrolysis; Petrochemicals and Fine Chemicals, Refineries, Bulk Chemicals, & Nuclear Industry

Textbook(s)
1. David Reay, Colin Ramshaw, and Adam Harvey, "Process Intensification: Engineering for Efficiency, Sustainability and Flexibility" Butterworth-Heinemann, 2008
2. Frerich J. Keil, "Modeling of Process Intensification", Wiley-VCH, 2007

Reference(s)
1. Relevant journal publications.

23CHE363 RENEWABLE ENERGY RESOURCES AND SYSTEMS L-T-P-C: 3-0-0-3

Course Objectives:

- To understand various non-renewable and renewable energy sources and working principles of the different systems and technologies available for effectively utilizing renewable energy sources.
- To outline the use of renewable energy sources in domestic and industrial scale systems and processes and their environmental impacts.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Recognize various non-renewable and renewable sources of energy and methods to utilize them
CO2:	Design systems, processes, and equipment for the effective utilization of renewable energy resources
CO3:	Assess systems and technologies suitable for large-scale energy production and storage in industries and chemical plants
CO4:	Analyse environmental impacts and cost of energy production from various renewable sources

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1										2	1	
CO2	3	3	3	3									3	3	1
CO3	3	3	1										3	2	2
CO4	1	2					2	2					2	2	3

Syllabus

Unit 1

Energy resources and their utilization: Conservation and forms of energy, Energy and sustainable development, Global and Indian energy scenario, Fossil energy, Nuclear power, Hydroelectric power potential, Renewable energy sources, Energy parameters, Cogeneration, Environmental impacts of power generation from nonrenewable and renewable energy sources, Environmental awareness-Kyoto protocol, Copenhagen climate change summit.

Unit 2

The solar energy system, Solar Radiation, Availability, Measurement and Estimation, Solar thermal conversion devices and storage, Laws of thermal radiation, Total loss coefficient and heat losses, Solar tracking, Solar concentrators, Solar photovoltaics, photovoltaic effect, Solar cell parameters, Semiconductors for solar cells, Applications of solar photovoltaics, grid-interactive solar PV system, PV hybrid system, Wind energy conversion, Site selection, Types of wind turbines, Wind farms, factors influencing wind, wind data and energy estimation, wind speed monitoring, classification of wind, characteristics, applications of wind turbines, offshore wind energy hybrid systems, wind resource assessment, wind energy conversion devices.

.

Unit 3

Ocean wave energy conversion, principle of Ocean Thermal Energy Conversion (OTEC), ocean thermal power plants, tidal energy conversion, Tidal and wave energy its scope and development, Small hydro power plant: Importance and elements, types of turbines for small hydro, estimation of primary and secondary power. Geothermal Energy: power plants, types, hot springs, and steam ejection. Biogas plant technology and status, Bioenergy system, design, and construction. Biomass resources and their classification, Biomass conversion processes, biomass gasification, pyrolysis and liquefaction, biochemical conversion, anaerobic digestion, types of biogas plants, applications, alcohol production from biomass, biodiesel production, Urban waste to energy conversion, Biomass energy program in India.

Textbook(s)

1. J. W. Twidell and A. Weir, "Renewable Energy Sources," 2nd Edition, Taylor and Francis Group, 2006.
2. V.V.N. Kishore, "Renewable Energy Engineering and Technology," Teri Press, New Delhi, 2012.
3. D.P. Kothari, K.C. Singal, and R. Ranjan, "Renewable Energy Sources and Emerging Technologies," 2nd Edition, PHI Learning Private Limited, 2011.
4. Godfrey Boyle, "Renewable Energy, Power for a Sustainable Future, Oxford University Press," U.K, 1996.

23CHE364 **Safety and Hazard Management in Chemical Industries**

L-T-P-C: 3-0-0-3

Prerequisite: Introduction to Chemical Engineering, Solid and Fluid Operations, Chemical Technology

Course Objectives

To understand the importance of safety in workplace and undertake various hazard and operability studies.

Course Outcomes

After the completion of this course, student will be able to

CO1:	Identifying the typical sources of risks in a process plants by hazard identification and examination of case studies
CO2:	Evaluate the workplace to determine occupational safety and health hazards
CO3:	Select appropriate control methodologies to prevent hazards in industries
CO4:	Undertake a Hazard and Operability Studies (HAZOP)

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2			2						3	2	2
CO2	3	3	3	2			2						3	2	2
CO3	3	3	3	3			2						3	2	2
CO4	3	3	3	3			2		2				3	3	2

Syllabus

Unit 1

Hazard identification: General hazards of plant operation toxic hazards, fire and explosions – hazards. Transport of chemicals with safety unforeseen deviations, emergency management, planning for safety, selecting a basics of safety – preventive and protective measures, safety based on emergency, relief systems, safety based on containment operational safety procedural instructions – routine checks, process and product changes, safety checks, checklist for safety, leaks and detection.

Unit 2

Hazards of plant operation: Toxic hazards, fire and explosion hazards, reaction hazards, literature calculations & explosions screening, normal reaction, gas evolution, characterizing runaway, control and mitigation of gas emanations, absorption with chemical reaction, health and environmental effects. Special problem of developing countries, safety gadgets, dispersions, degree of hazards, disposals, hierarchy of options, threshold limits, laws of safety, accident reporting.

Unit 3

Storage, central handling safety, unintentional spills, runoff emits, containment economics, waste disposal and environmental protection, incineration, alternatives. Risk analysis, evaluation, mitigation, Hazop, Hazan, definition, probability quantification – risk, engineering, clean technology, initiatives, standards, emergency handling, accident investigation, legislation, nil-risk quantification methods. Case histories of accidents, examples of hazards assessment, examples of use of Hazan, explosion hazards in batch units, technical process, documentation for hazardous chemicals, format and methods.

Text book(s)

1. A. K. Rohatgi, “Safety handling of Hazardous Chemicals”, J.K. Enterprises, Mumbai, 1986.
2. S.K.Shukla, “Enviro Hazards and Techno Legal Aspects”, Shashi Publications, Jaipur, 1993.
3. G.L. Wells and R.M.C. Seagrave, “Flow sheeting for safety”, Institution of Chemical Engineering, London, 1977.

Reference(s)

1. T. Kletz, “Learning from Accidents”, 3rd Edition, Gulf Professional Publishing, London, 1988.
2. J. Barton and R. Rogers, “Chemical Reaction Hazards – A Guide to Safety”, Institution of Chemical Engineering, Gulf Professional Publishing, London, 1997.

23CHE365 SUSTAINABLE ENGINEERING AND LIFE CYCLE ANALYSIS L-T-P-C: 3-0-0-3

Course Objectives

The objective of the course is to make students understand the scientific basis to apply life cycle analysis (LCA) and assess the environmental sustainability

Course Outcomes

After the completion of this course, student will be able to

CO1:	Conduct LCA according to the ISO 14040 standards
CO2:	Comprehend concepts of sustainable engineering in process/product design and interpret LCA results
CO3:	Connect life cycle inventory (LCI) and life cycle impact assessment (LCIA) including the social and economic dimensions
CO4:	

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

CO Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
COO1	3	2	2			2	2				1		2	1	2
COO2	3	2	2			2	2				1		2	1	1
COO3	3	2	2			2	2				1		2	1	1
COO4	3	2	2			2	2				1		2	1	1

Syllabus

Unit 1

Introduction to Sustainability Concepts and Life Cycle Analysis (Introduction, Material flow and waste management, : Risk and Life Cycle Framework for Sustainability (Introduction, Risk, Environmental Risk Assessment, Example Chemicals and Health Effects, Character of Environmental Problems) Environmental Data Collection and LCA Methodology (Environmental Data Collection Issues, Statistical Analysis of Environmental Data, Common Analytical Instruments, Overview of LCA Methodology - Goal Definition, Life Cycle Inventory, Life Cycle Impact Assessment, Life Cycle Interpretation, LCA Software tools)

Unit 2

Life Cycle Assessment – Detailed Methodology and ISO Framework (Detailed Example on LCA Comparisons, LCA Benefits and Drawbacks, Historical Development and LCA Steps from ISO Framework, Life Cycle Inventory and Impact Assessments (Unit Processes and System Boundary Data Quality, Procedure for Life Cycle Impact Assessment, LCIA in Practice with Examples, Interpretation of LCIA Results, Factors for Good LCA Study (ISO Terminologies, LCA Steps Recap, Chemical Release and Fate and Transport, and Green Sustainable Materials)

Unit 3

Simplified/streamlined Life Cycle Assessments - procedural approaches, numerical approaches - Examples of numerical approaches - contribution analysis, perturbation analysis, uncertainty analysis, comparative analysis, key issue analysis - Treatment of uncertainties - Elements in uncertainty handling - Sensitivity of LCA results - Introduction of sustainability concepts; principles and indicators of sustainability; Quantification of sustainability, The concept of green engineering; Process/product design; Pollution prevention; Process life cycle; and Green technology and sustainability. Sustainability analysis - Extending LCA - economic dimension, social dimension - Life cycle costing - Eco-efficiency - Combining LCA and LCC – LCA case studies from International Journal of Life Cycle Assessment, Journal Cleaner Production and Journal of Industrial Ecology etc. on Product Design, Product Improvement, Product Comparison and Policy development.

Textbook(s)

1. Marry Ann Curan, Environmental Life Cycle Assessment, Mc Graw Hill New York 1996
2. International Organization for Standardization: ISO 14040 series of Standards for Life Cycle Analysis , 1997
3. Wimmer W, Zust R, Lee K . Ecodesign Implementation: A systematic guidance to integrating environmental considerations into product development. Springer, 2004

Reference(s)

1. International Organization for Standardization: ISO TR 14062 Environmental management - Integrating environmental aspects into product design and development, 2002.
2. David F Ciambrone , Environmental Life Cycle Analysis, CRC Press LLC, 1997 6 UNEP/SETAC UNEP/SETAC LifeCycle Initiative website, http://www.uneptie.org /sustain / lnitiative , 2004

23CHE366 **WASTE TO ENERGY CONVERSION** **L-T-P-C: 3-0-0-3**

Pre-Requisites: Chemical Process Calculations, Energy Balance and Thermodynamics, Chemical Reaction Engineering

Course Objectives

As part of this course, students would be taught on types of waste and waste characteristics in terms of their energy content and composition followed by the estimation of energy content of waste and different ways to convert to waste to energy / value-added chemicals.

Course Outcomes:

After the completion of this course, student will be able to

CO1:	Explain the different ways of classification waste generated based on the phase and waste source
CO2:	Determine the energy content of the waste using experimental and theoretical methods depending the type of waste and establish a relationship between composition and energy content
CO3:	Explain the different ways of waste to energy conversion technologies based on the product profiles and type of energy obtained and processing
CO4:	Design and evaluate different energy conversion catalysts and technologies

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2					3	3						3		
CO2	2	2				3	3						3		
CO3	3	3	3	3		3	3					3	3	3	3
CO4	3	3	3	3	3	3	3					3	3	3	3
CO5															

Syllabus

Unit 1

Waste – energy content, waste classification, waste composition, and waste segregation; Introduction to gasification, pyrolysis and combustion technology(s);

Unit 2

Pyrolysis of waste to liquid fuels – Thermal, catalytic / thermal, catalyst and reactor choice for pyrolysis; Gasification to liquid fuels via synthesis gas route – Petrol and Diesel production, Processes for waste to value-added chemicals via synthesis gas– Hydrogen production, methanol production, ethanol production – Design and catalyst choice for various technologies;

Unit 3

Gasification to Electricity – A Case study; Biomass – Classification and Composition; Biomass pyrolysis and gasification to syngas and sequential conversion to engine grade fuels – catalyst and equipment design; Conversion of biogas to hydrogen – comparison of dry reformation and steam reformation

Textbook(s)

1. Gary C. Young, Municipal Solid Waste Conversion Processes, John Wiley & Sons Inc., 2010
2. Marc J. Rogoff and Francois Screve, Waste to Energy: Technologies and Project Implementation, 2nd Edition, Elsevier Inc., 2011.
3. Prabir Basu, Biomass Gasification and Pyrolysis: Practical Design, 2010

Reference(s)

1. Avraam Karagiannidis, Waste to Energy, Springer-Verlag Limited., 2012
2. Selected Journal Articles

23CHE367 WASTEWATER TREATMENT TECHNOLOGIES AND DESIGN L-T-P-C: 3-0-0-3

Pre-Requisite: None

Course Objectives

The objective of the course is to understand industrial sector pollution problems and wastewater treatment technologies and design unit operations for the treatment of wastewater.

Course Outcomes

At the end of the course students would be able to:

CO1:	Explain the design and operational concepts of different wastewater treatment units
CO2:	Provide an outlook on disposal options of sludge from wastewater treatment units and by-product recovery
CO3:	Apply fundamental engineering science to the design of systems for the treatment of industrial water

CO-PO-PSO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

CO Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO01	3	2	2				2				1		2	1	2
CO02	3	2	2				2				1		2	1	1
CO03	3	2	2				2				1		2	1	1

Syllabus

Unit 1

Wastewater Treatment System – wastewater characteristics, primary, secondary and tertiary treatments, measurement of treatment efficiencies, environmental pollution control, biofilms in treatment of wastewater, biofilm development and biofilm Kinetics. Conventional biological process: Activated Sludge Process (ASP), UASB and Trickling Filters. Biological waste treatment: RBC, Nitrogen removal: Nitrification and denitrification process, phosphorous removal, aeration system, anaerobic filters. Low-cost wastewater treatment: Aerated lagoons, stabilization ponds, oxidation ditches.

Unit 2

Tertiary Treatment of Wastewater :Tertiary treatment – ion exchange, Membrane separation Techniques: Brief description of MF, UF, NF membranes. Reverse osmosis principle, Membrane materials, Types of membranes – Plate & frame, tubular, hollow fibre, spiral wound membranes, application of membranes in various industrial applications., electro chemical techniques : electro dialysis, electro coagulation, Evaporators : forces evaporation, Multiple effect evaporators – falling film, raising film, forced circulation, agitated thin film driers. Advanced oxidation process, photo catalysis.

Unit 3

Industrial Wastewater Treatment : Sources, Characteristics, methodology and process for the treatment of Industrial wastes of sugar industry- beverage industry – tannery industry – textile mill waste industry – fertilizer plant – steel plant – oil refinery – paper and pulp mill. Legislation, Cleaner technologies: Water conservation.

Textbook(s):

1. Reynolds, T. D., and P. A. Richards. Unit Operations and Processes in Environmental Engineering. 2nd ed. Boston, MA: PWS Publishing Company, 1996. ISBN: 0534948847.
2. Waste Water Engineering, Treatment and Reuse by Metcalf and Eddy, fifth edition, Tata McGraw Hill.
3. Treatise on Rural, Municipal, and industrial water management KVSG Murali Krishna.
4. S.P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill, 2001.

Reference(s):

1. Environmental pollution and Toxicology, Meera Asthana and Asthana D.K., Alka Printers (1994).
2. Tchobanoglous, G., F. L. Burton, and H. D. Stensel. Wastewater Engineering: Treatment and Reuse. 4th ed. Metcalf and Eddy Inc., New York, NY: McGraw-Hill, 2003. ISBN: 0070418780

23EEE321	POWER PLANT INSTRUMENTATION	L-T-P-C: 3-0-0-3

Pre-requisites: Energy Systems, Control Systems

Course Objective

To acquaint with theory and working principles of different types of instruments and control used in power plant automation.

Course Outcome

CO1: Familiarity with various components/equipment in power plants.
CO2: Understanding on process in different stages of power generation and transmission systems.
CO3: Familiarity with monitoring and control of boiler and turbine systems.
CO4: Exposure to automation of power plants.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	1	-	-	-	-	-	-	-
CO2	3	1	-	-	-	-	-	-	-	-	-	-	-	-
CO3	3	-	-	-	-	-	-	-	-	-	-	-	`-	-
CO4	3	-	1	-	2	-	-	-	-	-	-	-	2	-

Syllabus

Unit1

Introduction to Unit operation and Unit Process: Material and Energy Balance. Significance of Instrumentation and layout of thermal, hydroelectric, nuclear, gas turbine, solar, wind Power plants.
Concept of regional and national power grid. Concept of distance protections and islanding types of power plant.
Instrumentation and Equipments of Various Unit Operations: Evaporation, Distillation, leaching, Gas Absorption, Heat exchangers, Humidification and Dehumidification, Drying, Size Reduction, Crystallization, Mixing.

Unit2

Boiler Instrumentation and Optimization: Combustion control, 3 element drum level control, steam pressure, oxygen/CO/CO_2 – flue gases control, furnace draft, boiler interlocks, Start-up and shut-down procedures Boiler load calculation, boiler efficiency calculation.
SCADA controls- Boiler inspection and safety procedures.
Turbine Instrumentation and Control: Valve actuation, auto-start up, start up and shut down, thermal stress control, condition monitoring and Power Distribution Instrumentation. Auxiliary control of water treatment plant, Electrostatic Precipitator and Oil Automation System.

Unit 3

Automation: Thermal power plant, Boiler Automation – Diagnostic Functions and Protection – Digital Electro – Hydraulic Governor, Man-Machine Interface- Graphic Display of Automated Power plant.
Simulation experiments on SCADA, power plant monitoring and so on.

Text Book(s)

McCabe W.L, Smith J, Peter Harriot, "Unit operation of chemical Engineering", Seventh rev Edition, Tata McGraw Hill Publishing Company, , 2005.
Popovic and Bhatkar, "Distributed Computer control in Industrial automation", Second Edition, CRC Press, 1990.

Reference(s)

B.G.Liptak, "Instrument Engineers Handbook: Process Measurement and Analysis", Third Edition, Butterworth Heinemann, 1995.

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

23ECE343 WIRELESS SENSOR NETWORKS L-T-P-C: 3-0-0-3

Pre Requisite(s): Computer Networks

Couse Objectives

- To understand the characteristics and architecture of wireless sensor network
- To understand Physical and MAC layers in protocol stack and analyze various design considerations
- To attain a knowledge of Routing techniques and Data gathering Protocols
- To analyze and interpret wireless sensor network design in different applications scenario

Course Outcomes

CO1: Able to understand characteristics and architecture of wireless sensor network
CO2: Able to understand Physical and MAC layers in protocol stack and analyze its various design considerations
CO3: Able to understand various routing techniques in wireless sensor networks
CO4: Able to analyze and interpret wireless sensor network design in different applications scenario

CO – PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	2	1	-	-	-	-	-	-	-	-	-	-	-
CO3	3	1	1	-	-	-	-	-	-	-	-	-	-	-
CO4	2	2	2	-	-	-	-	-	1	-	-	-	-	-

Unit I

Introduction to WSN - Characteristic requirements for WSN - Challenges for WSNs – WSN vs Adhoc Networks Sensor node architecture – Commercially available sensor nodes – Imote - IRIS, Mica Mote, EYES nodes – Btnodes - TelosB, Sunspot -Physical layer and transceiver design considerations in WSNs - Energy usage profile Choice of modulation scheme - Dynamic modulation scaling -Antenna considerations - Medium Access Control Protocols - Fundamentals of MAC protocols - Low duty cycle protocols and wakeup concepts – Contention based protocols - Schedule-based protocols - SMAC - BMAC - Traffic-adaptive medium access protocol (TRAMA) - The IEEE 802.15.4 MAC protocol.

Unit 2

Routing And Data Gathering Protocols - Routing Challenges and Design Issues in Wireless Sensor Networks, Flooding and gossiping – Data centric Routing – SPIN – Directed Diffusion – Energy aware routing - Gradient- based routing - Rumor Routing – COUGAR – ACQUIRE – Hierarchical Routing - LEACH, PEGASIS – LocationBased Routing - GF - GAF - GEAR - GPSR – Real Time routing Protocols – TEEN – APTEEN – SPEED - RAP

- Data aggregation - data aggregation operations - Aggregate Queries in Sensor Networks - Aggregation Techniques – TAG - Tiny DB.

Unit 3

Embedded Operating Systems - Operating Systems for Wireless Sensor Networks – Introduction - Operating System Design Issues - Examples of Operating Systems – Tiny OS – Mate – Magnet OS – MANTIS - OSPM - EYES OS – Sen OS – EMERALDS – Pic OS Applications Of WSN: WSN Applications - Home Control – Building Automation - Industrial Automation - Medical Applications - Reconfigurable Sensor Networks - Highway Monitoring - Military Applications - Civil and Environmental Engineering Applications - Wildfire Instrumentation - Habitat Monitoring - Nanoscopic Sensor Applications – Case Study: IEEE 802.15.4 LR- WPANs Standard - Target detection and tracking - Contour/edge detection - Field sampling.

Text Book(s)

Holger Karl and Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley &Sons, Ltd, 2005.
Kazem Sohraby, Daniel Minoli and Taieb Znati, "Wireless Sensor Networks Technology, Protocols, andApplications", John Wiley & Sons, 2007.

Reference(s)

K. Akkaya And M. Younis, "A Survey Of Routing Protocols In Wireless Sensor Networks", Elsevier Ad-HocNetwork Journal, Vol. 3, No. 3, Pp. 325—349.
Anna Ha´C, "Wireless Sensor Network Designs", John Wiley & Sons Ltd.

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

23MAT321 PROBABILITY AND RANDOM PROCESSES L-T-P-C: 3

Course objectives

To understand the concepts of basic probability and random variables. To understand some standard distributions and apply to some problems.
To understand the concepts of random process, stationarity and autocorrelation functions. To understand markov process and markov chain and related concepts.

Course Outcomes

CO1: Understand the basic concepts of probability and probability modeling.
CO2: Gain knowledge about statistical distributions of one and two dimensional random variables and correlations
CO3: Understand the basic concepts of stochastic processes and the stationarity.
CO4: Understand the purpose of some special processes
CO5: Gain knowledge about spectrum estimation and spectral density function

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	-	-	-	-	-	-	-	-	-	-	-
CO2	3	3	3	-	-	-	-	-	-	-	-	-	-	-
CO3	3	3	2	-	-	-	-	-	-	-	-	-	-	-
CO4	3	2	2	-	-	-	-	-	-	-	-	-	-	-
CO5	2	2	2	-	-	-	-	-	-	-	-	-	-	-

Module I

Review of probability concepts - conditional probability- Bayes theorem.
Random Variable and Distributions: Introduction to random variable – discrete and continuous random variables and its distribution functions- mathematical expectations – moment generating function and characteristic function.

Module II

Binomial, Poisson, Geometric, Uniform, Exponential, Normal distribution functions (moment generating function, mean, variance and simple problems) – Chebyshev's theorem.

Module III Stochastic Processes:
General concepts and definitions - stationary in random processes - strict sense and wide sense stationary processes - autocorrelation and properties- special processes – Poisson points, Poisson and Gaussian processes and properties- systems with stochastic inputs - power spectrum- spectrum estimation, ergodicity –Markov process and Markov chain, transition probabilities, Chapman Kolmogrov theorem, limiting distributions classification of states. Markov decision process.

Text Book(s)
Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, (2005) John Wiley and Sons Inc.
A. Papoulis, and Unnikrishna Pillai, "Probability, Random Variables and Stochastic Processes", Fourth Edition, McGraw Hill, 2002.

Reference Book(s)
J. Ravichandran, "Probability and Random Processes for Engineers", First Edition, IK International, 2015. Scott L. Miller, Donald G. Childers, "Probability and Random Processes", Academic press, 2012.

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

23CSE325 MACHINE LEARNING L-T-P-C: 3

Pre-Requisite(s): 19MAT112 Linear Algebra, 19MAT205 Probability and Random Processes

Course Objectives

- The aim of this course is to provide foundational knowledge in machine learning.
- The students will learn to implement, train and validate the machine learning models and understand the recent algorithms in machine learning through case studies.

Course Outcomes

CO1: Understand issues and challenges of machine learning: data, model selection, model complexity
CO2: Design and implement various machine learning algorithms in a range of real-world applications
CO3: Understand strengths and weaknesses of many popular machine learning approaches

CO4: Analyze the underlying mathematical relationships within and across Machine Learning algorithms
CO5: Apply the paradigms of supervised and un-supervised learning

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	3									3	2
CO2	3	2	3	2	2			1					3	2
CO3	3	2	3	2	3								3	2
CO4	3	1	2	1	2								3	2
CO5	3	1	2	1				2					3	2

Syllabus

Unit 1
Foundations of supervised learning - Decision trees and inductive bias, Regression Vs Classification, Supervised: Linear Regression, Logistic Regression, Generalisation, Training, Validation and Testing, Problem of Overfitting, Bias vs Variance, Performance metrics, Decision Tree, Random Forest, Perceptron, Beyond binary classification

Unit 2

Advanced supervised learning - Naive Bayes, Bayesian Belief Network, K-Nearest Neighbour, Support vector machines, Markov model, Hidden Markov Model, Parameter Estimation : MLE and Bayesian Estimate, Expectation Maximisation, Neural Networks

Unit 3

Unsupervised Learning : Curse of Dimensionality, Dimensionality Reduction Techniques, Principal component analysis, Linear Discriminant Analysis Clustering: K-means, Hierarchical, Spectral, subspace clustering, association rule mining. Case Study: Recommendation systems

Text Book(s)

Tom Mitchell. Machine Learning. McGraw Hill; 2017

Reference(s)

Christopher M Bishop. Pattern Recognition and Machine Learning. Springer 2010
Richard O. Duda, Peter E. Hart, David G. Stork. Pattern Classification. Wiley, Second Edition;2007
Kevin P. Murphey. Machine Learning, a probabilistic perspective. The MIT Press Cambridge, Massachusetts, 2012.

Evaluation Pattern:

Assessment	Internal	External
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	15	
Continuous Assessment (Lab) (CAL)	30	
End Semester		35

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CSE327 NEURAL NETWORKS AND DEEP LEARNING L-T-P-C: 3

Pre-Requisite(s):19MAT111 Multivariable Calculus, 19MAT112 Linear Algebra, 19MAT205 Probability and Random Processes, 19CSE305 Machine Learning

Course Objectives

- This course provides an introduction to deep neural network models, and surveys some of the applications of these models in areas where they have been particularly successful.
- The course covers feedforward networks, convolutional networks, recurrent and recursive networks, as well as general topics such as input encoding and training techniques.

Course Outcomes

CO1: Understand the learning components of neural networks and apply standard neural network models to learning problems.
CO2: Analyze the learning strategies of deep learning – regularization, generalization, optimization, bias and variance.
CO3: Analyze regular deep learning models for training, testing and validation in standard datasets.
CO4: Apply neural networks for deep learning using standard tools.
CO5: Understand the mathematics for Deep learning.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	3									3	2
CO2	3	2	3	2	2								3	2
CO3	3	2	3	2	3								3	2
CO4	3	1	2	1	2								3	2
CO5	3	1	2	1									3	2

Syllabus

Unit 1

Perceptrons – classification - limitations of linear nets and perceptrons - multi-Layer Perceptrons (MLP)- activation functions - linear, softmax, tanh, ReLU; error functions - feed-forward networks - Backpropagation - recursive chain rule (backpropagation) - Learning weights of a logistic output -Loss functions - learning via gradient descent - optimization – momentum method; Adaptive learning rates – RmsProp - mini-batch gradient descent - bias-variance trade off, regularization - overfitting - inductive bias – regularization - drop out - generalization.

Unit 2

Probabilistic Neural Network **-** Hopfield Net, Boltzman machine, RBMs, Sigmoid net, Autoencoders; Conditional Random Fields **-** Linear chain, partition function, Markov network, Belief propagation, Training CRFs, Hidden Markov Model, Entropy.

Unit 3

Introduction to deep learning - Deep neural networks - convolutional nets – case studies using Keras/Tensorflow - neural nets for sequences - Recurrent Nets – Long-Short-Term-memory; Introduction to Deep unsupervised learning – PCA to autoencoders.

Text Book(s)
Ian Goodfellow, Yoshua Bengio and Aaron Courville. Deep Learning, MIT Press, Second Edition; 2016.

Reference(s)
Duda, R.O., Hart, P.E., and Stork, D.G. Pattern Classification. Wiley-Interscience. Second Edition;2001.Theodoridis, S. and Koutroumbas, K. Pattern Recognition. Fourth Edition. Academic Press;2008.
Russell, S. and Norvig, N. Artificial Intelligence: A Modern Approach. Prentice Hall Series in Artificial Intelligence;2003.
Bishop, C. M. Neural Networks for Pattern Recognition. Oxford University Press;1995.
Hastie, T., Tibshirani, R. and Friedman, J. The Elements of Statistical Learning. Springer;2001.Koller, D. and Friedman, N. Probabilistic Graphical Models. MIT Press;2009.

Evaluation Pattern

Assessment	Internal	External
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	10	
Continuous Assessment (Lab) (CAL)	40	
End Semester		30

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23MAT322 PROBABILITY AND STATISTICS L-T-P-C: 2-1-0-3

Course objectives

The course is expected to enable the students
- To understand discrete and continuous random variables and to compute important measures.
- To carry out various statistical tests and to draw practical inferences.

Course outcomes

CO1: To find out probabilistic measures of discrete and continuous random variables.
CO2: To conduct tests of hypothesis and tests of significance and to arrive at inferences.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1		1	1							2	1	1
CO2	1	1	1		1						1	1	2	1

Syllabus

Probability – Probability models and axioms, conditioning and Bayes' rule
Discrete random variables; probability mass functions; expectations, examples, multiple discrete random variables:joint PMFs, expectations, conditioning, independence

Continuous random variables, probability density functions, expectations, examples, multiple continuous randomvariables, continuous Bayes rule, covariance and correlation.
Statistics – Bayesian statistical inference, point estimators, parameter estimators, test of hypotheses, tests ofsignificance.

Text book

Introduction to Probability, D. Bertsekas and J. Tsitsiklis, 2nd Edition, Athena Scientific, 2008.

Evaluation Pattern

Assessment	Weightage
Test 1 (after 15th lecture hr)	25
*Continues Assessment (CA)	25
Test 2 (after 30th Lecture hr)	50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MAT323 OPTIMIZATION TECHNIQUES L-T-P-C: 3-0-0-3

Course Objective: To introduce various optimization methods applicable to engineering systems.

Course Outcomes:

CO1: Understanding of the logics of various optimization techniques.

CO2: Ability to formulate and solve optimization problems.

CO3: Ability to interpret and analyze the solutions of optimization algorithms.

CO4: Ability to use software tools in engineering design optimization problems.

Course Articulation Matrix: Correlation level [1: low, 2: medium, 3:High)

PO/PSO *CO*	*PO1*	*PO2*	*PO3*	*PO4*	*PO5*	*PO6*	*PO7*	*PO8*	*PO9*	*PO10*	*PO11*	*PO12*	*PSO1*	***PSO2***
CO1	3	1		-	-	-	-	-	-	-	-	-	-	-
CO2	3	3		1	-	-	-	-	-	-	-	-	-	-
CO3	3	2	-	2	-	-	-	-	-	-	-	-	-	-
CO4	3		1	-	2	-	-	-	-	-	-	-	1	1

Syllabus:

Unit 1

Introduction: Optimization – optimal problem formulation, engineering optimization problems, optimization algorithms, numerical search for optimal solution, graphical method, simplex method, Big M method, Two phase method.

Unit 2

Single variable optimization: Optimality criteria, bracketing methods- exhaustive search method, bounding phase method-region elimination method-interval halving, Fibonacci search, golden section search, interpolation methods, point estimation method- successive quadratic search, gradient based method. Case study and Simulation.

Unit3

Multivariable optimization: Optimality criteria, unconstrained optimization- solution by direct substitution unidirectional search- direct search methods, simultaneous uni-directional method- steepest descent method, shortest path algorithm Hook-Jeeves pattern search method, gradient based method. Newton's method, Conjugate gradient method, constrained optimization-Kuhn- Tucker, Lagrange multiplier method. Case Studies and simulation.

Stochastic methods of optimization: random search methods, evolutionary computation-Introduction, Survival of the Fittest, Fitness Computation, Cross over, Mutation, Reproduction, Particle Swarm Optimization, Introduction to Multi-objective optimization. Case study and Simulation.

Text Books/ References:

1. *S. S. Rao, "Optimization Theory & Applications", New Age international ltd. Publishers, Second edition, 1995*
2. *Kalyanmoy Deb, "Optimization for Engineering Design Algorithms & Examples" Prentice Hall of India, New Delhi 2004.*
3. *Edwin K. P. Chong, and Stanislaw H. Zak, "An Introduction to optimization", Wiley- interscience series in discrete mathematics and optimization, second edition, 2004.*
4. *M. Asghar Bhatti, "Practical optimization methods with mathematics applications", Springer Verlag Publishers, 2000.*
5. *G. A Vijayalakshmi Pai & S. Rajashekharan " Neural Network, Fuzzy Logic, Genetic Algorithms Synthesis & Applications", PH India, 2003.*

Evaluation Pattern

50:50 (Internal: External)

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

Courses offered under the framework of

Amrita Values Programmes I and II

22AVP201 Message from Amma's Life for the Modern World

Amma's messages can be put to action in our life through pragmatism and attuning of our thought process in a positive and creative manner. Every single word Amma speaks and the guidance received in on matters which we consider as trivial are rich in content and touches the very inner being of our personality. Life gets enriched by Amma's guidance and She teaches us the art of exemplary life skills where we become witness to all the happenings around us still keeping the balance of the mind.

22ADM211 Leadership from the Ramayana

Introduction to Ramayana, the first Epic in the world – Influence of Ramayana on Indian values and culture – Storyline of Ramayana – Study of leading characters in Ramayana – Influence of Ramayana outside India – Relevance of Ramayana for modern times.

22ADM201 Strategic Lessons from the Mahabharata

Introduction to Mahabharata, the largest Epic in the world – Influence of Mahabharata on Indian values and culture – Storyline of Mahabharata – Study of leading characters in Mahabharata – Kurukshetra War and its significance - Relevance of Mahabharata for modern times.

22AVP204 Lessons from the Upanishads

Introduction to the Upanishads: Sruti versus Smrti - Overview of the four Vedas and the ten Principal Upanishads - The central problems of the Upanishads – The Upanishads and Indian Culture – Relevance of Upanishads for modern times – A few Upanishad Personalities: Nachiketas, SatyakamaJabala, Aruni, Shvetaketu.

22AVP205 Message of the Bhagavad Gita

Introduction to Bhagavad Gita – Brief storyline of Mahabharata - Context of Kurukshetra War – The anguish of Arjuna – Counsel by Sri. Krishna – Key teachings of the Bhagavad Gita – Karma Yoga, Jnana Yoga and Bhakti Yoga - Theory of Karma and Reincarnation – Concept of Dharma – Concept of Avatar - Relevance of Mahabharata for modern times.

22AVP206 Life and Message of Swami Vivekananda

Brief Sketch of Swami Vivekananda's Life – Meeting with Guru – Disciplining of Narendra - Travel across India - Inspiring Life incidents – Address at the Parliament of Religions – Travel in United States and Europe – Return and reception India – Message from Swamiji's life.

22AVP207 Life and Teachings of Spiritual Masters India

Sri Rama, Sri Krishna, Sri Buddha, AdiShankaracharya, Sri Ramakrishna Paramahamsa, Swami Vivekananda, Sri RamanaMaharshi, Mata Amritanandamayi Devi.

22AVP208 Insights into Indian Arts and Literature

The aim of this course is to present the rich literature and culture of Ancient India and help students appreciate their deep influence on Indian Life - Vedic culture, primary source of Indian Culture – Brief introduction and appreciation of a few of the art forms of India - Arts, Music, Dance, Theatre.

22AVP209 Yoga and Meditation

The objective of the course is to provide practical training in YOGA ASANAS with a sound theoretical base and theory classes on selected verses of Patanjali's Yoga Sutra and Ashtanga Yoga. The coverage also includes the effect of yoga on integrated personality development.

22AVP210 Kerala Mural Art and Painting

Mural painting is an offshoot of the devotional tradition of Kerala. A mural is any piece of artwork painted or applied directly on a wall, ceiling or other large permanent surface. In the contemporary scenario Mural painting is not restricted to the permanent structures and are being done even on canvas. Kerala mural paintings are the frescos depicting mythology and legends, which are drawn on the walls of temples and churches in South India, principally in Kerala. Ancient temples, churches and places in Kerala, South India, display an abounding tradition of mural paintings mostly dating back between the 9th to 12th centuries when this form of art enjoyed Royal patronage. Learning Mural painting through the theory and practice workshop is the objective of this course.

22AVP213 Traditional Fine Arts of India

India is home to one of the most diverse Art forms world over. The underlying philosophy of Indian life is 'Únity in Diversity" and it has led to the most diverse expressions of culture in India. Most art forms of India are an expression of devotion by the devotee towards the Lord and its influence in Indian life is very pervasive. This course will introduce students to the deeper philosophical basis of Indian Art forms and attempt to provide a practical demonstration of the continuing relevance of the Art.

22AVP214 Principles of Worship in India

Indian mode of worship is unique among the world civilizations. Nowhere in the world has the philosophical idea of reverence and worshipfulness for everything in this universe found universal acceptance as it in India. Indian religious life even today is a practical demonstration of the potential for realization of this profound truth. To see the all-pervading consciousness in everything, including animate and inanimate, and constituting society to realise this truth can be seen as the epitome of civilizational excellence. This course will discuss the principles and rationale behind different modes of worship prevalent in India.

22AVP215 Temple Mural Arts in Kerala

The traditional percussion ensembles in the Temples of Kerala have enthralled millions over the years. The splendor of our temples makes art enthusiast spellbound, warmth and grandeur of color combination sumptuousness of the outline, crowding of space by divine or heroic figures often with in vigorous movement are the characteristics of murals.

The mural painting specially area visual counterpart of myth, legend, gods, dirties, and demons of the theatrical world, Identical myths are popular the birth of Rama, the story of Bhīma and Hanuman, Shiva, as Kirata, and the Jealousy of Uma and ganga the mural painting in Kerala appear to be closely related to, and influenced by this theatrical activity the art historians on temple planes, wood carving and painting the architectural plane of the Kerala temples are built largely on the pan-Indians almost universal model of the Vasthupurusha.

22AVP218 Insights into Indian Classical Music

The course introduces the students into the various terminologies used in Indian musicology and their explanations, like Nadam, Sruti, Svaram – svara nomenclature, Stayi, Graha, Nyasa, Amsa, Thala,- Saptatalas and their angas, Shadangas, Vadi, Samavadi, Anuvadi. The course takes the students through Carnatic as well as Hindustani classical styles.

22AVP219 Insights into Traditional Indian Painting

The course introduces traditional Indian paintings in the light of ancient Indian wisdom in the fields of aesthetics, the Shadanga (Sixs limbs of Indian paintings) and the contextual stories from ancient texts from where the paintings originated. The course introduces the painting styles such as Madhubani, Kerala Mural, Pahari, Cheriyal, Rajput, Tanjore etc.

22AVP220 Insights into Indian Classical Dance

The course takes the students through the ancient Indian text on aesthetics the Natyasastra and its commentary the AbhinavaBharati. The course introduces various styles of Indian classical dance such as Bharatanatyan, Mohiniyatton, Kuchipudi, Odissy, Katak etc. The course takes the students through both contextual theory as well as practice time.

22AVP221 Indian Martial Arts and Self Defense

The course introduces the students to the ancient Indian system of self-defense and the combat through various martial art forms and focuses more on traditional Kerala's traditional KalariPayattu. The course introduces the various exercise technique to make the body supple and flexible before going into the steps and techniques of the martial art. The advanced level of this course introduces the technique of weaponry.

PROFESSIONAL ELECTIVES UNDER SCIENCE STREAM

CHEMISTRY

23CHY240	COMPUTATIONAL CHEMISTRY AND MOLECULAR MODELLING	L-T-P-C: 3-0-0-3

Course Outcomes:

CO1: Get to understand the structure of molecules using symmetry.
CO2: Understanding Quantum mechanical approach to calculate the energy of a system.
CO3: Applying mathematical knowledge and quantum mechanical approach in finding out the characteristics-reactivity, stability, etc., of the molecule.
CO4: To get a brief idea about molecular mechanics based chemical calculations. CO5: To get an idea about general methodology of molecular modeling.

Syllabus

Unit 1
Introduction: Stability, symmetry, homogeneity and quantization as the requirements of natural changes - Born - Haber cycle – Energetic – kinetics - Principles of spectra.

Computational techniques: Introduction to molecular descriptors, computational chemistry problems involvingiterative methods, matrix algebra, Curve fitting.

Molecular mechanics: Basic theory - Harmonic oscillator – Parameterization - Energy equations - Principle ofcoupling - Matrix formalism for two masses - Hessian matrix - enthalpy of formation - enthalpy of reactions.

Introduction to Quantum mechanics - Schrodinger equation - Position and momentumMO formation - Operators and the Hamiltonian operator - The quantum oscillator Oscillator Eigen value problems - Quantum numbers - labeling of atomic electrons.

Unit 2

Molecular Symmetry: Elements of symmetry - Point groups - Determination of point groups of molecules.

Huckel's MO theory: Approximate and exact solution of Schrodinger equation - Expectation value of energy - Huckel's theory and the LCAO approximation - Homogeneous simultaneous equations - Secular matrix - Jacobi method - Eigen vectors: Matrix as operator - Huckel's coefficient matrix - Wheeland's method - Hoffmann's EHTmethod - Chemical applications such as bond length, bond energy, charge density, dipole moment, Resonance energy.

Unit 3

Self consistent fields: Elements of secular matrix - Variational calculations - Semi empirical methods - PPP self consistent field calculation - Slater determinants - Hartree equation - Fock equation – Roothaan - Hall equation - Semi empirical models and approximations.

Ab-initio calculations: Gaussian implementations – Gamess - Thermodynamic functions - Koopman's theorem - Isodesmic reactions, DFT for larger molecules - Computer aided assignments/mini projects with softwares - Introduction to HPC in Chemical calculations.

Molecular modelling software engineering - Modeling of molecules and processes

Signals and signal processing in Chemistry - QSAR studies and generation of molecular descriptors - Applications of chemical data mining - Familiarization with open source softwares useful for molecular modeling - Introduction tomolecular simulation - M.D. simulation.

TEXTBOOKS:

1. *K. I. Ramachandran, G Deepa and K Namboori, "Computational Chemistry and Molecular Modeling - Principles and Applications", Springer-Verlag, Berlin, Heidelberg, 2008, ISBN-13 978-3-540-77302-3.*
2. *Donald W Rogers, "Computational Chemistry Using PC", Wiley, (2003).*
3. *Alan Hinchliffe, "Chemical Modeling from atoms to liquids", Wiley, (2005).*

REFERENCES:

1. *James B Forseman and Aeleen Frisch-Gaussian, "Exploring Chemistry with Electronic Structure Method", Inc., Pittsburgh, PA, 2nd edition, (2006).*
2. *A C Philips, "Introduction to Quantum mechanics", Wiley, (2003).*
3. *Wolfram Koch, Max C. Holthausen, "A Chemist's guide to Density Functional Theory", Wiley, VCH, 2nd edition, (2001).*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CHY241	ELECTROCHEMICAL ENERGY SYSTEMS AND PROCESSES	L-T-P-C: 3-0-0-3

Course Outcomes:

CO1: Understand the fundamental concepts of electrochemistry through electrode potential and reaction kinetics
CO2: Learn the application of the electrochemical principles for the functioning and fabrication of industrial batteries and fuel cells
CO3: Acquire knowledge in solving numerical problems on applied electrochemistry
CO4: Analysis and practical problem solving in fabrication of batteries and fuel cells
CO5: Application of concepts and principle in industrial electrochemical processes
CO6: Evaluation of comprehensive knowledge through problem solving

SyllabusUnit

1
Background Theory: Origin of potential - electrical double layer - reversible electrode potential - standard hydrogen electrode - emf series - measurement of potential - reference electrodes (calomel and silver/silver chloride) indicatorand ion selective electrodes - Nernst equation - irreversible processes - kinetic treatment - Butler- Volmer equation -Overpotential, activation, concentration and IR overpotential - its practical significance - Tafel equation and Tafelplots - exchange current density and transfer coefficients.

Unit 2
Batteries: Primary batteries: The chemistry, fabrication and performance aspects, packing classification and rating of the following batteries: (The materials taken their function and significance, reactions with equations, their performance in terms of discharge, capacity, and energy density to be dealt with). Zinc-carbon (Leclanche type), zinc alkaline (Duracell), zinc/air, zinc-silver oxide batteries; lithium primary cells - liquid cathode, solid cathode and polymer electrolyte types and lithium-ferrous sulphide cells (comparative account).

Secondary batteries: ARM (alkaline rechargeable manganese) cells, Lead acid and VRLA (valve regulated (sealed)lead acid), nickel-cadmium, nickel-zinc, nickel- metal hydride batteries, lithium ion batteries, ultra thin lithium polymer cells (comparative account). Advanced Batteries for electric vehicles, requirements of the battery - sodium-beta and redox batteries.

Unit 3
Reserve batteries and Fuel cells: Reserve batteries - water activated, electrolyte activated and thermally activated batteries - remote activation - pyrotechnic materials. Fuel Cells: Principle, chemistry and functioning - carbon, hydrogen- oxygen, proton exchange membrane (PEM), direct methanol(DMFC), molten carbonate electrolyte (MCFC) fuel cells and outline of biochemical fuel cells.

Electrochemical Processes: Principle, process description, operating conditions, process sequence and applications of Electroforming – production of waveguide and plated through hole (PTH) printed circuit boards by electrodeposition; Electroless plating of nickel, copper and gold; Electropolishing of metals; Anodizing of aluminium; Electrochemical machining of metals and alloys.

TEXTBOOKS:

1. *Derek Pletcher and Frank C. Walsh, "Industrial Electrochemistry", Blackie Academic and Professional, (1993).*
2. *Dell, Ronald M Rand, David A J, "Understanding Batteries", Royal Society of Chemistry, (2001).*

REFERENCES:

1. *Christopher M A, Brett, "Electrochemistry – Principles, Methods and Applications", Oxford University, (2004).*
2. *Watanabe T, "Nano-plating: microstructure control theory of plated film and data base of plated film microstructure", Elsevier, Oxford, UK (2004).*
3. *Kanani N, "Electroplating and electroless plating of copper and its alloy", ASM International, Metals Park, OH and Metal Finishing Publications, Stevenage, UK (2003).*
4. *Lindon David, "Handbook of Batteries", McGraw Hill, (2002).*
5. *Curtis, "Electroforming", London, (2004).*

6. *Rumyantsev E and Davydov A, "Electrochemical machining of metals", Mir, Moscow, (1989).*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CHY242	FUELS AND COMBUSTION	L-T-P-C: 3-0-0-3

Course Objectives:

To provide the basic knowledge about fuels, rocket propellants and explosives.

Course Outcomes:

CO1: Understand the types of fuels and variation in their properties
CO2: Able to analyze the fuel content
CO3: Obtain knowledge in identifying a proper fuel as per the requirement
CO4: Ability to know the preparation and working of propellants and explosives

SyllabusUnit

1
Fuels - Solid fuels - Classification, preparation, cleaning, analysis, ranking and properties - action of heat, oxidation, hydrogenation, carbonization, liquefaction and gasification.

Liquid fuels – Petroleum - origin, production, composition, classification, petroleum processing, properties, testing -flow test, smoke points, storage and handling.

Secondary liquid fuels - Gasoline, diesel, kerosene and lubricating oils. Liquid fuels - refining, cracking, fractional distillation, polymerization. Modified and synthetic liquid fuels. ASTM methods of testing the fuels.

Unit 2
Gaseous fuels - Types, natural gas, methane from coal mine, water gas, carrier gas, producer gas, flue gas, blast furnace gas, biomass gas, refinery gas, LPG - manufacture, cleaning, purification and analysis. Fuels for spark ignition engines, knocking and octane number, anti knock additives, fuels for compression, engines, octane number, fuels forjet engines and rockets.

Flue gas analysis by chromatography and sensor techniques.

Unit 3
Combustion: Stochiometry, thermodynamics. Nature and types of combustion processes - Mechanism - ignition temperature, explosion range, flash and fire points, calorific value, calorific intensity, theoretical flame temperature. Combustion calculations, theatrical air requirements, flue gas analysis, combustion kinetics – hydrogen - oxygen reaction and hydrocarbon - oxygen reactions.

Rocket propellants and Explosives - classification, brief methods of preparation, characteristics; storage and handling.

TEXTBOOK:

1. *Fuels and Combustion, Samir Sarkar, Orient Longman Pvt. Ltd, 3rd edition, 2009.*

REFERENCES:

1. *Fuels - Solids, liquids and gases - Their analysis and valuation, H. Joshua Philips, Biobliolife Publisher, 2008.*
2. *An introduction to combustion: Concept and applications - Stephen R Turns, Tata Mc. Graw Hill, 3rd edition, 2012.*
3. *Fundamentals of Combustion, D P Mishra, 1st edition, University Press, 2010*
4. *Engineering Chemistry - R. Mukhopadhyay and Sriparna Datta, Newage International Pvt. Ltd, 2007.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CHY243	GREEN CHEMISTRY AND TECHNOLOGY	L-T-P-C: 3-0-0-3

Course Objectives:

1. Understand the principles of green chemistry and its contribution to the development of sustainable products
2. Possess knowledge of the migration from a hydrocarbon-based economy to carbohydrate-based economy
3. Evaluate the deficiencies of traditional process and acknowledge the invent of new processes
4. Distinctly map the culmination of academic research to industrial chemistry

Course Outcomes:

CO1: Understand the evolving concept of Green Chemistry and its application to the manufacture of sustainable products
CO2: Appreciate the need for Renewable energy and Feed stock along with carbon sequestration through the fundamentals of Green Chemistry Techniques
CO3: Develop a coherence to evaluate systematic deficiencies in traditional Chemical science process and products
CO4: Undertake a purposeful Journey through the microscopic domain of academic research to the macroscopic domain of Industrial chemistry

Syllabus Unit

1
Our environment and its protection, chemical pollution and environmental regulations, environmental chemistry, pollution prevention strategies, challenges to the sustainability of chemical industry, Pollution Prevention Act 1990,USA, Green Chemistry and its 12 principles, toxicity of chemicals, material safety data sheet (MSDS), concept of zero pollution technologies, atom economy, functional toxicity vs non-functional toxicity, alternative solvents, energy minimization, microwave and sonochemical reactions, renewable feed stock, carbon dioxide as a feed stock.

Unit 2
Greener strategies of the synthesis of ibuprofen synthesis, teriphthalic acid etc. phase behaviour and solvent attributes of supercritical CO2, use of supercritical carbon dioxide as a medium chemical industry, use of ionic liquids as a synthetic medium, gas expanded solvents, superheated water, etc. Synthesis of various chemicals from bio mass, polycarbonate synthesis and CO2 fixation, green plastics, green oxidations, etc.

Unit 3
Processes involving solid catalysts – zeolites, ion exchange resins, Nafion/silica nano composites and enhanced activity. Polymer supported reagents, green oxidations using TAML catalyst, membrane reactors. Green chemistry in material science, synthesis of porous polymers, green nanotechnology.

REFERENCES:

1. *Hand Book of Green Chemistry and Technology; by James Clarke and Duncan Macquarrie; Blakwell Publishing.*
2. *Anastas, P. T., Warner, J. C. Green Chemistry: Theory and Practice, Oxford University Press Inc., New York, 1998.*
3. *Matlack, A. S. Introduction to Green Chemistry Marcel Dekker: New York, NY, 2001.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CHY244	INSTRUMENTAL METHODS OF ANALYSIS	L-T-P-C: 3-0-0-3

Course Outcomes:

CO1: To develop an understanding of principle and working of the range of instrumental methods in analytical chemistry
CO2: To provide an understanding and skills in contemporary methods of separation and appropriate selection of instruments for the successful analysis of chemical compounds
CO3: To impart skills in the scientific method of planning, conducting, reviewing, reporting experiments and problem solving in chemical analysis.

SyllabusUnit

1
Error Analysis and Sampling: Accuracy - Precision - Classification of Errors -Minimization of errors - Standard deviation - Coefficient of variance - F-test - t-test - Significant figures. Sampling - Basis of sampling, Sampling andphysical state - Safety measures of sampling.

Separation Techniques: Brief out line of column, paper and thin layer chromatography - Ion exchange methods - principle and application – HPLC.

Unit 2
Gas chromatography - principle and applications – gel chromatography.

Electroanalytical techniques: Potentiometry - Potentiometric titration - determination of equivalence point - acidbase, complexometric, redox and precipitation titrations - merits and demerits. Voltammetry - Cyclic voltammetry - basic principle and application - Polarography - introduction - theoretical principles - migration current - residual current - half wave potential - instrumentation - analytical applications.

Unit 3
Spectro-chemical techniques: UV-VIS spetrophotometry - principle - Beer's Law application - photometric titration - single and double beam spectrophotometer - instrumentation of IR - sample handling - IR applications - H - NMR - Instrumentation and applications – principle - instrumentation - applications of atomic absorption spectroscopy.

Thermal and Diffraction techniques: Principles and applications of DTG - DTA DSC - X-ray - Electron DiffractionStudies - SEM, TEM.

TEXTBOOKS:

1. *Willard H W, Merritt J R, "Instrumental Methods of Analysis", 6th edition, Prentice Hall, (1986).*
2. *Skoog Douglas A, West Donald, "Fundamentals of Analytical Chemistry", 7th edition, New York Addison, Wesley, (2001).*

REFERENCES:

1. *"Vogel's Textbook of Quantitative Chemical Analysis", 5th edition, ELBS, (1989).*
2. *Kaur. H, "Instrumental Methods of Chemical Analysis", Goel Publisher, (2001).*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CHY245	BATTERIES AND FUEL CELLS	L-T-P-C: 3-0-0-3

Course Objective:

To provide sound knowledge on the application of electrochemistry in energy storage systems.

Course Outcome

CO1: Understand the fundamental concepts of electrochemistry through electrode potential and reaction kinetics
CO2: Learn the application of the electrochemical principles for the functioning and fabrication industrial batteries and fuel cells
CO3: Analysis of practical problem solving in fabricating batteries and fuel cells
CO4: Evaluation of comprehensive knowledge through problem solving

SyllabusUnit

1
Background Theory: Origin of potential - electrical double layer - reversible electrode potential - standard hydrogen electrode - emf series - measurement of potential - reference electrodes (calomel and silver/silver chloride) indicatorand ion selective electrodes - Nernst equation - irreversible processes - kinetic treatment - Butler- Volmer equation -Overpotential, activation, concentration and IR overpotential - its practical significance - Tafel equation and Tafelplots - exchange current density and transfer coefficients.

Unit 2
Batteries: Primary batteries: The chemistry, fabrication and performance aspects, packing classification and rating of the following batteries: (The materials taken their function and significance, reactions with equations, their performance in terms of discharge, capacity, and energy density to be dealt with). Zinc-carbon (Leclanche type), zinc alkaline (Duracell), zinc/air batteries; Lithium primary cells - liquid cathode, solid cathode and lithium-ferrous sulphide cells (comparative account).

Secondary batteries: Lead acid and VRLA (valve regulated (sealed) lead acid), nickel-cadmium, nickel-zinc, nickel-metal hydride batteries, lithium ion batteries, ultrathin lithium polymer cells (comparative account). Advanced Batteries for electric vehicles, requirements of the battery - sodium-beta and redox batteries.

Unit 3
Fuel Cells: Description, working principle, anodic, cathodic and cell reactions, fabrication of electrodes and other components, applications, advantages, disadvantages and environmental aspects of the following types of fuel cells:Proton Exchange Membrane Fuel Cells, alkaline fuel cells, phosphoric acid, solid oxide, molten carbonate, direct methanol fuel cells.

Membranes for fuel cells: Nafion – Polymer blends and composite membranes; assessment of performance – recent developments.

Fuels for Fuel Cells: Hydrogen, methane, methanol - Sources and preparation, reformation processes for hydrogen –clean up and storage of the fuels – use in cells, advantages and disadvantages of using hydrogen as fuel.

TEXTBOOKS:

1. *Dell, Ronald M Rand, David A J, 'Understanding Batteries', Royal Society of Chemistry, (2001).*
2. *M. Aulice Scibioh and B. Viswanathan 'Fuel Cells – principles and applications', University Press, India (2006).*

REFERENCES:

1. *Kanani N, 'Electroplating and electroless plating of copper and its alloy', ASM International, Metals Park,*

OH and Metal Finishing Publications, Stevenage, UK (2003).

2. *Curtis, 'Electroforming', London, (2004).*
3. *F. Barbir, 'PEM fuel cells: theory and practice', Elsevier, Burlington, MA, (2005).*
4. *G. Hoogers, 'Fuel cell handbook', CRC, Boca Raton, FL, (2003).*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CHY246	CORROSION SCIENCE	L-T-P-C: 3-0-0-3

Course Outcome:

CO1: Development of skill in identifying the nature and type of corrosion
CO2: Understanding the mechanism of various types of corrosion
CO3: Analysing the problem and find out a solution to combat corrosion in any sort of environment.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	-	-	-	-	-	-	-	-	-	-	3	1	-	-
CO2	-	3	1	2	-	-	-	-	-	-	-	1	1	2	-	-
CO3	-	3	3	3	2	3	3	-	-	-	-	1	3	2	3	-

Syllabus Unit

1
Basic principles: Free energy concept of corrosion - different forms of corrosion - Thermodynamic & Kinetic aspects of corrosion: The free energy criterion of corrosion possibility - Mechanism of Electrochemical corrosion - Galvanic and Electrochemical series and their significance.

Corrosion Control: Materials selection - metals and alloys - metal purification - non metallic - changing medium.

Unit 2
Anodic and cathodic protection methods - Coatings - metallic and other inorganic coatings - organic coatings - stray current corrosion - cost of corrosion control methods.

Corrosion protection by surface treatment: CVD and PVD processes - Arc spray - Plasma spray - Flame spray. Corrosion

Inhibitors: Passivators - Vapour phase inhibitor.

Unit 3
Stress and fatigue corrosion at the design and in service condition - control of bacterial corrosion.

Corrosion protection: Automobile bodies – engines – building construction.

TEXTBOOKS:

1. *Fontana and Mars G, "Corrosion Engineering", 3rd edition, McGraw Hill, (1987).*
2. *Uhlig H H and Reviees R W, "Corrosion and its Control", Wiley, (1985).*

REFERENCES:

1. *ASM Metals Handbook, "Surface Engineering", Vol. 5, ASM Metals Park, Ohio, USA, (1994).*
2. *ASM Metals Handbook, "Corrosion", Vol. 13, ASM Metals Park, Ohio, USA, (1994).*
3. *Brain Ralph, "Material Science and Technology", CRC Series, Boston, New York.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

PHYSICS

23PHY240	ADVANCED CLASSICAL DYNAMICS	L-T-P-C: 3-0-0-3

Course Outcomes:

CO1: Able to use the Lagrangian formalism to solve simple dynamical system

CO2: Able to understand Hamiltonian formalism and apply this in solving dynamical systems

CO3: Able to apply Lagrangian formalism in bound and scattered states with specific reference to Kepler's laws and Scattering states

CO4: Able to solve problems in the Centre of Mass frame and connect it to Laboratory Frame of Reference

CO5: Understand and solve problems in rigid body rotations applying of Euler's equations.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	0	0	0	0	0	0	0	1	0	0	0
CO2	3	3	1	1	0	0	0	0	0	0	0	1	0	0	0
CO3	3	3	3	1	0	0	0	0	0	0	0	1	0	0	0
CO4	3	3	3	1	0	0	0	0	0	0	0	2	0	0	0
CO5	3	3	3	2	0	0	0	0	0	0	0	2	0	0	0

SyllabusUnit

1

Introduction to Lagrangian dynamics

Survey of principles, mechanics of particles, mechanics of system of particles, constraints, D'Alembert's principle and Lagrange's equation, simple applications of the Lagrangian formulation, variational principles and Lagrange's equations, Hamilton's principles, derivation of Lagrange's equations from Hamilton's principle, conservation theorems and symmetry properties.

Unit 2

Central field problem

Two body central force problem, reduction to the equivalent one body problem, Kepler problem, inverse square lawof force, motion in time in Kepler's problem, scattering in central force field, transformation of the scattering to laboratory system, Rutherford scattering, the three body problem.

Rotational kinematics and dynamics

Kinematics of rigid body motion, orthogonal transformation, Euler's theorem on the motion of a rigid body.

Unit 3

Angular momentum and kinetic energy of motion about a point, Euler equations of motion, force free motion of rigid body.

Practical rigid body problems

Heavy symmetrical spinning top, satellite dynamics, torque-free motion, stability of torque-free motion - dual-spin spacecraft, satellite maneouvering and attitude control - coning maneuver - Yo-yo despin mechanism - gyroscopicattitude control, gravity- gradient stabilization.

TEXTBOOKS:

1. *H. Goldstein, Classical Mechanics, Narosa Publishing House, New Delhi, 1980, (Second Edition)*
2. *H. Goldstein, Charles Poole, John Safko, Classical Mechanics, Pearson education, 2002 (Third Edition)*
3. *Howard D. Curtis, Orbital Mechanics for Engineering Students, Elsevier, pp.475 - 543*
4. *Anderson John D, Modern Compressible flow, McGraw Hill.*

REFERENCE BOOKS:

1. *D. A. Walls, Lagrangian Mechanics, Schaum Series, McGraw Hill, 1967.*
2. *J. B. Marion and S. T. Thornton, Classical dynamics of particles and systems, Ft. Worth, TX: Saunders, 1995.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23PHY241	ELECTRICAL ENGINEERING MATERIALS	L-T-P-C: 3-0-0-3

Course Outcomes

CO1: To understand the nature of interaction between atoms in crystalline solid materials that determines their dielectric, magnetic and electrical properties.

CO2: Analyze the relation between the macroscopic dielectric constant and the atomic structure of an insulator.

CO3: Fundamental concepts of magnetic fields required to illustrate the magnetic dipoles. This forms the basis to understand the magnetic properties of dia, para, ferro, antiferro and ferri magnetic materials.

CO4: Fundamentals concerned with conduction mechanism in metals and superconductors.

CO5: Understand the basics for classification of materials based on its conductivity, nature of chemical bonds inSi and Ge, carrier density, energy band structure and conduction mechanism in intrinsic and extrinsic semiconductors.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1											1	-
CO2	2	2	2										1	-
CO3	2	2	2										2	-
CO4	2	2	2										2	-
CO5	2	2	2					2					1	-

Syllabus Unit

1

Conducting materials: The nature of chemical bond, crystal structure Ohm's law and the relaxation time, collision time, electron scattering and resistivity of metals, heat developed in a current carrying conductor, thermal conductivity of metals, superconductivity.

Semiconducting materials: Classifying materials as semiconductors, chemical bonds in Si and Ge and it'sconsequences, density of carriers in intrinsic semiconductors, conductivity of intrinsic semiconductors, carrier densities in n type semiconductors, n type semiconductors, Hall effect and carrier density.

Unit 2

Magnetic materials: Classification of magnetic materials, diamagnetism, origin of permanent, magnetic dipoles in matter, paramagnetic spin systems, spontaneous magnetization and Curie Weiss law, ferromagnetic domains and coercive force, anti ferromagnetic materials, ferrites and it's applications.

Unit 3

Dielectric materials: Static dielectric constant, polarization and dielectric constant, internal field in solids and liquids, spontaneous polarization, piezoelectricity.

PN junction: Drift currents and diffusion currents, continuity equation for minority carriers, quantitative treatment of the p-n junction rectifier, the n-p-n transistor**.**

TEXTBOOK:

1. A J Decker, "Electrical Engineering materials", PHI, New Delhi, 1957.

REFERENCES:

1. *A J Decker, "Solid State Physics", Prentice Hall, Englewood Cliffs, N J 1957.*
2. *C Kittel, "Introduction to solid state Physics", Wieley, New York, 1956 (2nd edition).*
3. *Allison, Electronic Engineering materials and Devices, Tata Mc Graw Hill*
4. *F K Richtmyer E H Kennard, John N Copper, "Modern Physics", Tata Mc Graw Hill, 1995 (5th edition).*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23PHY242	PHYSICS OF LASERS AND APPLICATIONS	L-T-P-C: 3-0-0-3

Unit 1

Review of some basic concepts and principle of laser.

Introduction to light and its properties: Reflection, refraction, interference, diffraction and polarization. Photometry – calculation of solid angle. Brewster's law. Snell's law and, its analysis.

Introduction to LASERS: Interaction of radiation with matter - induced absorption, spontaneous emission, stimulated emission. Einstein's co-efficient (derivation). Active material. Population inversion – concept and discussion about different techniques. Resonant cavity.

Unit 2

Properties of LASERS

Gain mechanism, threshold condition for PI (derivation), emission broadening - line width, derivation of FWHM natural emission line width as deduced by quantum mechanics - additional broadening process: collision broadening, broadening due to dephasing collision, amorphous crystal broadening, Doppler broadening in laser and broadeningin gases due to isotope shifts. Saturation intensity of laser, condition to attain saturation intensity.

Properties – coherency, intensity, directionality, monochromaticity and focussibility. LASER transition – role of electrons in LASER transition, levels of LASER action: 2 level, 3 level and 4 level laser system.

Unit 3

Types of LASERS

Solid state LASER: (i) Ruby LASER – principle, construction, working and application. (ii) Neodymium (Nd) LASERS. gas LASER: (i) He-Ne LASER - principle, construction, working and application. (i) CO2 LASER - principle, construction, working and application.

Liquid chemical and dye LASERS. Semiconductor LASER: Principle, characteristics, semiconductor diode LASERS, homo-junction and hetero-junction LASERS, high power semi conductor diode LASERS.

Applications in Communication field:

LASER communications: Principle, construction, types, modes of propagation, degradation of signal, analogue communication system, digital transmission, fiber optic communication.

Applications of LASERS in other fields:

Holography: Principle, types, intensity distribution, applications. laser induced fusion. Harmonic generation. LASER spectroscopy. LASERS in industry: Drilling, cutting and welding. Lasers in medicine: Dermatology, cardiology, dentistry and ophthalmology.

REFERENCES:

1. *William T Silfvast, "Laser Fundamentals", Cambridge University Press, UK (2003).*
2. *B B Laud, "Lasers and Non linear Optics", New Age International (P) Ltd., New Delhi.*

3. *Andrews, "An Introduction to Laser Spectroscopy (2e)", Ane Books India (Distributors).*
4. *K R Nambiar, "Lasers: Principles, Types and Applications", New Age International (P) Ltd., New Delhi.*
5. *T Suhara, "Semiconductor Laser Fundamentals", Marcel Dekker (2004).*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23PHY243	CONCEPTS OF NANOPHYSICS AND NANOTECHNOLOGY	L-T-P-C: 3-0-0-3

Course Outcomes

CO1: Understand, Comprehend and acquaint with concepts of NanoPhysics
CO2: To familiarize the material's property changes with respect to the dimensional confinements.
CO3: Acquire knowledge on the modern preparation process and analysis involved in the nanomaterial's research
CO4: To learn about the technological advancements of the nano-structural materials and devices in the engineering applications

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2												
CO2	2	3												
CO3				3										
CO4						3	2					1		

Syllabus Unit 1

Introduction

Introduction to nanotechnology, comparison of bulk and nanomaterials – change in band gap and large surface to volume ratio, classification of nanostructured materials. Synthesis of nanomaterials - classification of fabrication methods – top down and bottom up methods.

Concept of quantum confinement and phonon confinement

Basic concepts – excitons, effective mass, free electron theory and its features, band structure of solids. Bulk to nano transition – density of states, potential well - quantum confinement effect – weak and strong confinement regime. Electron confinement in infinitely deep square well, confinement in two and three dimension. Blue shift of band gap
- effective mass approximation. Vibrational properties of solids - phonon confinement effect and presence of surfacemodes.

Unit 2

Tools for characterization:

Structural – X-ray diffraction, transmission electron microscope,scanning tunneling microscope, atomic force microscope. Optical - UV – visible absorption and photoluminescence techniques, Raman spectroscopy.

Nanoscale materials – properties and applications:

Carbon nanostructures – structure, electrical, vibration and mechanical properties. Applications of carbon nanotubes

Unit 3

Field emission and shielding – computers – fuel cells – chemical sensors – catalysis – mechanical reinforcement. Quantum dots and Magnetic nanomaterials – applications.

Nanoelectronics and nanodevices:

Impact of nanotechnology on conventional electronics. Nanoelectromechanical systems (NEMSs) – fabrication (lithography) and applications. Nanodevices - resonant tunneling diode, quantum cascade lasers, single electron transistors – operating principles and applications.

TEXTBOOKS:

1. *Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, Nanoscale Science and Technology, John Wiley and Sons Ltd 2004.*
2. *W. R. Fahrner (Ed.), Nanotechnology and Nanoelectronics, Springer 2006.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23PHY244	PHYSICS OF SEMICONDUCTOR DEVICES	L-T-P-C: 3-0-0-3

Course Outcomes:

CO1: Understand, comprehend and acquaint with the basics working principles and governing equations of electronic devices like diodes, Bipolar junction transistors, Mosfet and heterojunction transistors
CO2: Analyze and Solve physics problems pertaining to various process like charge conduction across semiconductor device.
CO3: Apply the knowledge for the development and design of new methods to determine semiconductor parameters and devices

SyllabusUnit

1

Introduction: Unit cell, Bravais lattices, crystal systems, crystal planes and Miller indices, symmetry elements. Defects and imperfections – point defects, line defects, surface defects and volume defects

Electrical conductivity: Classical free electron theory – assumptions, drift velocity, mobility and conductivity, drawbacks. quantum free electron theory – Fermi energy, Fermi factor, carrier concentration. Band theory of solids –origin of energy bands, effective mass, distinction between metals, insulators and semiconductors.

Unit 2

Theory of semiconductors: Intrinsic and extrinsic semiconductors, band structure of semiconductors, carrier concentration in intrinsic and extrinsic semiconductors, electrical conductivity and conduction mechanism in semiconductors, Fermi level in intrinsic and extrinsic semiconductors and its dependence on temperature and carrier concentration. Carrier generation - recombination, mobility, drift-diffusion current. Hall effect.

Theory of p-n junctions – diode and transistor:p-n junction under thermal equilibrium, forward bias, reverse bias, carrier density, current, electric field, barrier potential. V-I characteristics, junction capacitance and voltage breakdown.

Unit 3

Bipolar junction transistor, p-n-p and n-p-n transistors: principle and modes of operation, current relations. V-I characteristics. Fundamentals of MOSFET, JFET. Heterojunctions – quantum wells.

Semiconducting devices: Optical devices: optical absorption in a semiconductor, e--hole generation. Solar cells – p-n junction, conversion efficiency, heterojunction solar cells. Photo detectors – photo conductors, photodiode, p-i-n diode. Light emitting diode (LED) – generation of light, internal and external quantum efficiency.

Modern semiconducting devices: CCD - introduction to nano devices, fundamentals of tunneling devices, design considerations, physics of tunneling devices.

TEXTBOOKS:

1. *C Kittel, "Introduction to Solid State Physics", Wiley, 7th Edn., 1995.*
2. *D A Neamen, "Semiconductor Physics and Devices", TMH, 3rd Edn., 2007.*

REFERENCES:

1. *S M Sze, "Physics of Semiconductor Devices", Wiley, 1996.*
2. *P Bhattacharya, "Semiconductor Opto- Electronic Devices", Prentice Hall, 1996.*
3. *M K Achuthan & K N Bhat, "Fundamentals of Semiconductor Devices", TMH, 2007.*
4. *J Allison, "Electronic Engineering Materials and Devices", TMH, 1990.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23PHY245	ASTROPHYSICS	L-T-P-C: 3-0-0-3

Course Outcomes:

After completion of the course students should be able to

CO1: Get a broad knowledge of scientific and technical methods in astronomy and astrophysics.
CO2: Apply mathematical methods to solve problems in astrophysics.
CO3: Develop critical/logical thinking, scientific reasoning and skills in the area of modern astrophysics.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3											1		
CO2	2	2												
CO3	1	2												

SyllabusUnit

1

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 2

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 3

Galactic astronomy: Distance measurement - red shifts and Hubble's law – age of the universe, galaxies – morphology - Hubble's classification - gravitational lens, active galactic nuclei (AGNs), pulsars, quasars.

Relativity: Special theory of relativity - super-luminal velocity - Minkowski space - introduction to general theory of relativity – space - time metric, geodesics, space-time curvature. Advance of perihelion of Mercury, gravitational lens.

Cosmology: Comic principles, big bang and big crunch – cosmic background radiation - Nucleo-synthesis - planklength and time, different cosmic models - inflationary, steady state. Variation of G. anthropic principle.

REFERENCES:

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.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

MATHEMATICS

23MAT240	STATISTICAL INFERENCE	L-T-P-C: 3-0-0-3

Syllabus

Unit 1

Introduction to Statistics: Data Collection and Descriptive Statistics, Populations and Samples, describing data sets, summarizing data sets, Normal Data Sets, Paired Data Sets and the Sample Correlation Coefficient. Review of Random Variables and Distributions, Distributions of Sampling Statistics, The Sample Mean, The Central Limit Theorem, The Sample Variance, Sampling Distributions from a Normal Population, Distribution of the Sample Mean, Joint Distribution of $\overline{X}$ and S^2, Sampling from a Finite Population.

Unit 2

Parameter Estimation: Introduction, Maximum Likelihood Estimators, Interval Estimates, Estimating the Difference in Means of Two normal populations, Approximate Confidence Interval for the Mean of a Bernoulli random variable, Confidence Interval of the Mean of the Exponential Distribution, Evaluating a Point Estimator, The Bayes Estimator. Hypothesis Testing: Introduction, Significance Levels, Tests Concerning the Mean of a Normal Population, Testing the Equality of Means of Two Normal Populations, Hypothesis Tests Concerning the Variance of a Normal Population, Tests Concerning the Mean of a Poisson Distribution.

Unit 3

Regression: Introduction, Least Squares Estimators of the Regression Parameters, Distribution of the Estimators, Statistical Inferences about the Regression Parameters, the Coefficient of Determination and the Sample Correlation Coefficient, Analysis of Residuals, transforming to Linearity, Weighted Least Squares, Polynomial Regression, Multiple Linear Regression, Predicting Future Responses, Logistic Regression Models for Binary Output Data.

TEXTBOOK:

1. Ross S.M., Introduction to Probability and Statistics for Engineers and Scientists, 3rd edition, Elsevier Academic Press.

REFERENCES:

1. *Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley and Sons Inc., 2005*
2. *Ravichandran, J. Probability and Statistics for engineers, First Reprint Edition, Wiley India, 2012.*
3. *Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, Probability and Statistics for Engineers and Scientists, 8th Edition, Pearson Education Asia, 2007.*
4. *Hogg, R.V., Tanis, E.A. and Rao J.M., Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23MAT241	INTRODUCTION TO GAME THEORY	L-T-P-C: 3-0-0-3

Syllabus

Unit 1

Elements of Game theory, examples, Strategic Games, 2 Player Strategy Games, payoffs, Minimax, Weak and Strong Domination, Saddle Points, Nash Equilibrium, Prisoner's Dilemma, Stag Hunt, Matching pennies, BOS, Multi NE, Cooperative and Competitive Games, Strict and Non Strict NE, Best response functions for NE.

Unit 2

Combinatorial games, Winning and losing positions, Subtraction Game, 3-Pile and K-Pile Games, Proof of Correctness, Variations of K-Pile Games, Graph Games, Construction, Proof of finiteness, SG theorem for sum ofgames.

Unit 3

Cournot's Oligopoly, Bertrand's Oligopoly, Electoral Competition, Median Voter Theorem, Auctions, role of knowledge, Decision making and Utility Theory, Mixed Strategy Equilibrium, Extensive Games with Perfect Information, Stackelberg's model of Duopoly, Buying Votes, Committee Decision making, Repeated Gmes, Prisoner's Dilemma, Supermodular Game and Potential games

TEXTBOOK:

1. *Martin Osborne, An Introduction to Game Theory, Oxford University Press.*

REFERENCES:

1. *Thomas Ferguson, Game Theory, World Scientific, 2018.*
2. *Stef Tijs. Introduction to Game Theory, Hindustan Book Agency.*
3. *Allan MacKenzie, Game Theory for Wireless Engineers, Synthesis Lectures On Communications.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23MAT242	NUMERICAL METHODS AND OPTIMIZATION	L-T-P-C: 3-0-0-3

Syllabus

09 (a) Roots finding methods:
Roots of Transcendental and Polynomial Equations: Bisection method, Iteration methods based on first degree equation, Rate of convergence, system of nonlinear equations.

09 (b) Interpolations:
Interpolation and Approximation: Lagrange, Newton's Divided Difference, Newton's Forward and Backward interpolations.

07 (b) Multivariable optimization (2 Credits)
Optimality criteria – unidirectional search – direct search methods – gradient based methods. Lagrangian and Kuhn-Tucker conditions.

TEXTBOOK:

1. *Edwin K.P. Chong, Stanislaw H. Zak, "An introduction to Optimization", 2nd edition, Wiley, 2013.*
2. *M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical methods for scientific and Engineering computation, New Age International Publishers, 2007, 5th edition.*

REFERENCES:

1. *Kalyanmoy Deb, "Optimization for Engineering Design: Algorithms and Examples, Prentice Hall, 2002.*
2. *S.S. Rao, "Optimization Theory and Applications", Second Edition, New Age International (P) Limited Publishers, 1995.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

FREE ELECTIVES OFFERED UNDER MANAGEMENT STREAMCOMMON TO ALL PROGRAMS

23MNG331	**FINANCIAL MANAGEMENT**	**L-T-P-C: 3-0-0-3**

Course Objectives

- Understand the overview of financial management
- Inculcate methods and concepts on valuation
- Familiarize with working capital management, financial analysis and planning

Course Outcomes

CO1: Understand and apply time value concept of money and use this for investment criteria decisions.
CO2: Evaluate the risk and return for various alternatives of investment.
CO3: Apply the capital budgeting techniques and evaluate the investment decisions.
CO4: Understand working capital management, cash and liquidity management and financial statements**. CO/PO**

Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3					1	1		3	3	1			
CO2	3	3					2	1		3	3	1			
CO3	3	2					1	1		3	3	1			
CO4	3	2			1		2	1	2	3	3	1			

SyllabusUnit

1
Introduction: Financial Management an overview – Financial Decisions in a firm – Goal of FM – Function of the financial system.

Unit 2
Fundamental Valuation Concepts:Time value of money – Risk and Return. Capital Budgeting: Techniques of capital budgeting investment criteria– NPV – Benefit Cost Ratio – IRR – Payback Period – ARR – Investment appraisal inPractice – Estimation of Project cost flows.

Unit 3
Working Capital Management: Current Assets – Financing Ruling – Profit Criterion. Cash and Liquidity Management. Working Capital Financing.

Financial Analysis and Planning**:** financial instruments, sources of long-term, intermediate term and short term finance. Analyzing Financial Performance – Break – even analysis and Leverages – Financial Planning and Budgeting.

Mergers and Takeovers-International trade.

TEXT BOOKS

1. *Chandra, P., 'Financial Management: Theory and Practice', 9e, TMH, 2017.*
2. *Denzil Watson & Antony Head, 'Corporate Finance- Principles and Practice', 2e, Pearson Education Asia, 2016.*
3. *R L Varshney& K L. Maheshwari, 'Managerial Economics', S Chand & Sons, 22e, 2014.*

REFERENCE BOOKS

1. *Stephen Blyth, 'An Introduction to Corporate Finance ',McGraw Hill Book Company, 2014.*
2. *Eugene F. Brigham & Louis C.Gapenski, 'Financial Management – Theory and Practice',14e, 2015.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MNG332	SUPPLY CHAIN MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objectives

- Understand the complexity and key issues in supply chain management.
- Describe logistics networks, distribution planning, routing design and scheduling models.
- Familiarize dynamics of supply chain and the role of information in supply chain.
- Understand the issues related to strategic alliances, global supply chain management, procurement and outsourcing strategies.

Course Outcomes

CO1: Analyze the complexity and key issues in supply chain management

CO2: Evaluate single and multiple facility location problems, logistics network configuration, vehicle routing and scheduling models

CO3: Analyze inventory management models and dynamics of the supply chain

CO4: Develop the appropriate supply chain through distribution requirement planning and strategic alliances

CO5: Identify the issues in global supply chain management, procurement and outsourcing strategies

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1									1	3		
CO2	2	2	3	1						1	1	2	2		
CO3	3	3	3	3	2				3	1	1	3	2		
CO4	2	2	1	1						1	1	2	2		
CO5	3	3	3	1					3	1	1	3	2		

SyllabusUnit

1

Introduction: Introduction to SCM-the complexity and key issues in SCM – Location strategy – facility locationdecisions – single facility and multiple location models.

Logistics: Logistics Network Configuration – data collection-model and data validation- solution techniques-network configuration DSS – Transport strategy – Service choices: single service and inter modal services – vehicle routingand scheduling models – traveling salesman problems – exact and heuristic methods.

Unit 2

Inventory: Inventory Management and risk pooling-managing inventory in the SC. Value of Information-bullwhipeffect-lead time reduction.

Supply Chain Integration: Supply chain integration-distributed strategies-push versus pull systems. Distribution Requirements Planning – DRP and demand forecasting, DRP and master production scheduling. DRP techniques –time-phased order point – managing variations in DRP – safety stock determination-Strategic alliances-third partylogistics-distribution integration.

Unit 3

Issues in SCM**:** Procurement and outsourcing strategies – framework of e-procurement. International issues in SCM-regional differences in logistics. Coordinated product and supply chain design-customer value and SCM.

TEXT BOOK

Simchi-Levi,D.,Kaminsky,P.,Simchi-Levi,E., Shankar,R., 'Designing and Managing the Supply Chain: Concepts, Strategies, and Cases', Tata McGraw Hill, 2008.

REFERENCE BOOKS

1. *Christopher, M., 'Logistics and Supply Chain Management: Strtegies for reducing Cost and Improving Service', PH, 1999.*
2. *Ballou, M., 'Business logistics / Supply chain management', Pearson Education, 2003.*
3. *Vollmann, T.E., 'Manufacturing Planning and Control for Supply Chain Management', 5e, McGraw Hill, 2005.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MNG333	MARKETING MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objective

To educate the students to apply concepts and techniques in marketing so that they become acquainted with the duties of a marketing manager with an emphasis to make the students exposed to the development, evaluation, and implementation of marketing management in a variety of business environments.

Course Outcomes

On successful completion of the Course students will be able to:

CO1: Illustrate key marketing concepts, theories and techniques for analysing a variety of marketing situations
CO2: Identify and demonstrate the dynamic nature of the environment in which marketing decisions are taken and appreciate the implication for marketing strategy determination and implementation
CO3: Develop the ability to carry out a research project that explores marketing planning and strategies for a specific marketing situation
CO4: Understand the need and importance of sales promotions and make use of advertising
CO5: Manage a new product development process from concept to commercialization.
CO6: Illustrate the importance of modern trends in retailing and marketing logistics

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1			3	1								1			
CO2		1	3	3		2	1			2	2	2			
CO3	1	1	1	3	2	2	2		2	2	2	3			
CO4			2	2		2	1	1		3	3	3			
CO5	1	1	3	2		1	1			1	2	3			
CO6	1	1	3	2		1	1			1	2	3			

Syllabus Unit

1
Marketing Process: Definition, Marketing process, dynamics, needs, wants and demands, value and satisfaction, marketing concepts, environment, mix. Philosophies, selling versus marketing, organizations, industrial versus consumer marketing, consumer goods, industrial goods, product hierarchy.

Buying Behaviour and Market Segmentation: Major factors influencing buying behaviour, buying decision process, businessbuyingbehaviour. Segmenting consumer and business markets, market targeting.

UNIT 2
Product Pricing and Marketing Research: Objectives, pricing, decisions and pricing methods, pricing management. Introduction, uses, process of marketing research.

UNIT 3
Developing New Products - Challenges in new-product Development - Effective organizational arrangements - Managing the development Process: ideas - Concept to strategy - Development to commercialization – The consumer- adoption process. Advertising Sales Promotion and Distribution: Characteristics, impact, goals, types, and sales promotions- point of

purchase- unique selling proposition. Characteristics, wholesaling, retailing, channel design, logistics, and moderntrends in retailing.

TEXT BOOKS

1. *Kolter, P.,'Marketing Management', Pearson Education 2001.*
2. *Ramasamy and Namakumari, 'Marketing Environment: Planning, implementation and control the Indian context', 1990.*

REFERENCE BOOKS

1. *Paul, G.E. and Tull, D., 'Research for marketing decisions', Prentice Hall of India, 1975.*
2. *Tull, D.S. and Hawkins, 'Marketing Research', Prentice Hall of Inida-1997.*
3. *Kotler, P. and Armstrong, G., 'Principles of Marketing' Prentice Hall of India, 2000.*
4. *Skinner, S.J., 'Marketing', All India Publishers and Distributes Ltd. 1998.*
5. *Govindarajan, M., 'Industrial marketing management', Vikas Publishing Pvt. Ltd, 2003.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MNG334	PROJECT MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objectives

- To discuss the project life cycle and build a successful project from pre-implementation to completion.
- To introduce different project management tools and techniques

Course Outcomes

CO1: Appraise the selection and initiation of individual projects and its portfolios in an enterprise.
CO2: Analyze the project planning activities that will predict project costs, time schedule, and quality.
CO3: Develop processes for successful resource allocation, communication, and risk management.
CO4: Evaluate effective project execution and control techniques that results in successful project completion

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	2	1				2		3	1	2	3	2
CO2	2	3	3	2	2				3		3	2	2	3	3
CO3	1	2	3	2	2				2		3	2	1	2	3
CO4	1	1	2		1				2		3	1	1	1	2

SyllabusUnit

1

Overview of Project Management: Verities of project, Project Features, Project Life Cycle – S-Curve, J-C **Project Selection:** Project Identification and Screening – New ideas, Vision, Long-term objectives, SWOT Analysis (Strength, Weakness, Opportunities, Threats).
Project Appraisal – Market Appraisal, Technical Appraisal, Economic Appraisal, Ecological Appraisal, and Financial Appraisal – Payback, Net Present Value (NPV), Internal Rate of Returns (IRR).
Project Selection – Decision Matrix, Technique for Order Preference using Similarity to Ideal Solution (TOPSIS), Simple Additive Weighting (SAW).

Unit 2

Project Presentation: WBS, Project Network – Activity on Arrow (A-O-A), Activity on Node (A-O-N).**Project Scheduling:** Gant Chart, Critical Path Method (CPM), Project Evaluation & Review Technique (PERT).**(6hrs)**
Linear time cost trade-offs in project - Direct cost, indirect cost, Project crashingResource Consideration - Profiling, Allocation, Levelling.
Introduction to project management software: Primavera/ Microsoft project

Unit 3

Project Execution: Monitoring control cycle, Earned Value Analysis (EVA), Project Control – Physical control, Human control, financial control.
Organizational and Behavioral Issues: Organizational Structure, Selection-Project Manager, Leadership Motivation, Communication, Risk Management.
Project Termination: Extinction, Addition, Integration, Starvation.

TEXT BOOKS

1. *Jack R. Meredith and Samuel J. Mantel, Jr. - 'Project Management- A Managerial Approach' Eighth Edition - John Wiley & Sons Inc - 2012.*
2. *Arun Kanda – 'Project Management-A Life Cycle Approach' PHI Learning Private Limited - 2011*

REFERENCE BOOKS

1. *'A Guide to Project Management Body of Knowledge' PMBOK GUIDE, Sixth edition, Project management Institute – 2017*
2. *Ted Klastrorin - 'Project Management, Tools, and Trade-Offs' - John Wiley – 2011*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MNG335	ENTERPRISE MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objectives

- To impart knowledge on the fundamentals of costing, pricing methods and strategies.
- To give an overview of production operations planning.
- To summarize various quantitative methods of plant location, layout and lean manufacturing.
- To familiarize the concepts of e-commerce, e-purchasing, MRP and ERP in business

Course Outcomes

At the end of the course, the student will be able to:

CO1: Understand the concepts of cost and pricing of goods and appraise project proposals
CO2: Design and analyze manufacturing and service processes and to measure the work performed.
CO3: Understand and analyze the key issues of supply chain Management
CO4: Understand the application of lean manufacturing tools and six sigma concepts
CO5: Select appropriate plant location and their layout methods
CO6: Create capacity plan, aggregate plan, schedule, ERP & MRP systems

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1							2	2			
CO2	2	1								1		2	1		1
CO3	2	1										2	1		1
CO4	2	1	1	1						1		2	1		1
CO5	2	1		1								2			
CO6	2	2	1	1							1	2	1		1

Syllabus Unit

1

Engineering Economics: cost concepts - types of costs - cost functions. Cost controls: reduction – tools & applications.Pricing policies – methods – problems.Process design and improvement – process capacity – process layout – process reengineering – job design. Work standards – work measurement – work sampling – problems.

Unit 2

Supply Chain Management – Basic Concepts, SC dynamics, push-pull boundary, integrated supply chain, logistics, customer relationship, supplier relationship – selection, rating and development, procurement, SC metrics and performance measurement - problems. Lean Manufacturing – concepts, wastes – tools viz., pull system, standardized work, takt time, kanban system, JIT, kaizen, SMED, 5S, value stream mapping, benefits of lean and implementationissues. Introduction to Six Sigma. Plant Location – globalization, factors affecting location decisions, facility location- Break-even method, rectilinear, factor-rating and centre of gravity – problems. Plant Layout – types, process layout,product layout, Systematic layout planning (SLP), Line Balancing problems. Capacity Planning – Aggregate Planning – importance, planning process, methods – problems.

Unit 3

Role of IT in business performance improvement – e-commerce – e-purchasing –Master Production Schedule, inventory lot sizing strategies, MRP basics – MRP explosion, Available to Promise(ATP) inventory – MRP calculations – MRP II – Scheduling – Gantt chart – Introduction to ERP – ERP software – ERP modules – ERP implementation.

TEXT BOOKS

1. *L J Krajewski, L.P.RitzmanMalhotra.M and Samir K. Srivastava, 'Operations Management: Processes and Value chains, 11e, Pearson, 2015.*
2. *R L Varshney& K L. Maheshwari, 'Managerial Economics', S Chand & Sons, 22e, 2014.*

REFERENCE BOOKS

1. *Richard B. Chase, Ravi Shankar, F. Robert Jacobs, 'Operations and Supply Chain Management' McGraw Hill Education (India) Private Limited.14e, 2017.*
2. *E S Buffa and R K Sariss, 'Modern Production/Operations Management', Wiley India Private Limited, 8e, 2007.*
3. *Harrison.B, Smith.C., and Davis.B.,, 'Introductory Economics', 2e Pr Macmillan, 2013.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports.

23MNG336	OPERATIONS RESEARCH	L-T-P-C: 3-0-0-3

Course Objectives

Familiarizing the students with quantitative tools and techniques, which are frequently applied in operational decisions

Course Outcomes

CO1: Formulate operations research models to optimize resources.
CO2: Solve transportation and assignment problems using suitable techniques.
CO3: Apply appropriate technique to analyze a project with an objective to optimize resources.
CO4: Solve operational problems using decision theory approaches.
CO5: Select suitable inventory model for effective utilisation of resources.
CO6: Solve Operations Research problems using software package

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2		2						2	2	2		
CO2	3	2	2		2						2	2	2		
CO3	3	2	2		2						2	2	2		
CO4	3	2	2		2						2	2	2		
CO5	3	2	2		2						2	2	2		
CO6	3	2	2		2						2	2	2		

SyllabusUnit1
Linear Programming: Formulations - graphical solutions - Simplex Method - Duality, Dual simplex method.
Transportation model: Assignment model – Travelling Salesman Problem.

Unit 2
Decision Theory: Decision Trees. Game theory - 2 person zero sum; mixed strategies; 2 x n and m x 2 games. Network Models- Project Networks- CPM / PERT- Project Scheduling – crashing networks and cost considerations-Resource leveling and smoothing - shortest route problem, minimal spanning tree problem, maximal flow problem.

Unit 3
Sequencing model – 2 machines 'n' jobs, 'm' machines 'n' jobs – n jobs 2 machines.
Inventory models: deterministic & probabilistic models. Quantity discounts. Selective Inventory Management Queuing models: Poisson arrival and exponential service times. Single server, multi-server. Queues -infinite and finite capacity queues.
Simulation –Monte Carlo simulation: simple problems

Lab session: Practicing case problems with excel solver/MatLab/LINGO package

TEXT BOOK
Hillier, F .S. and Lieberman, G .J, 'Operations Research', 9e, McGraw Hill, 2010

REFERENCE BOOKS

1. *Taha,H.A., 'Operations Research: an Introduction', 8e, Prentice HalI, New Delhi, 2008.*
2. *Ravindran, A., Phillips, D.J., and Solberg, J.J., 'Operations Research- Principles and Practice', John Wiley & Sons, 2005.*
3. *Wagner, H.M., 'Principles of Operations Research', Prentice Hall, New Delhi, 1998.*

4. *Hardley, G.,'Linear Programming', Narosa Book Distributors Private Ltd 2002.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	15	
*Continuous Assessment(Lab) (CAL)	30	
End Semester		35

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MEE321	INDUSTRIAL ENGINEERING	L-T-P-C: 3-0-0-3

Course Objectives

- To inculcate the concepts of work study and its application to industrial practice
- Impart skills to design, develop, implement, and improve manufacturing/service systems

Course Outcomes

At the end of the course, the student will be able to

CO1: Create value to organizations through the analysis, evaluation, and improvement of work systems using work study and method study
CO2: Develop work systems through motion economy principles
CO3: Apply work measurement techniques to improve productivity, fix wages and incentives
CO4: Apply systematic layout planning techniques and work station design principles based on ergonomics and material handling.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	1						1		3	2		
CO2	2	1	2	1	1					1		3	2		
CO3	1	2		1	1						1	3	2		
CO4	2	2		1	2						2	3	2		

SyllabusUnit

1
Work System: Elements of work, maintenance of machines, interaction, effect of working conditions and environment, physical and mental fatigue.
Productivity: Productivity, factors affecting production, Measurement of productivity.
Work Study: Definition and scope of work study; Areas of application of work study in industry; Human aspects ofwork study.
Method Study: Information collection, recording techniques, and processing aids; critical examination; development, installation and maintenance of improved methods.

Unit 2
Motion Economy and Analysis: Principles of motion economy; Motion analysis; Micromotion and Memomotion study; Therbligs and SIMO charts; Normal work area and design of work places; Basic parameters and principles ofwork design.
Work Measurement: Work measurement techniques; Calculation of standard time, work sampling and predetermined Motion time systems.
Wages and Incentive Schemes: Introduction, wage payment of direct and indirect labour, wage payment plans and incentives, various incentive plans, incentives for indirect labour

Unit 3
Plant Layout: Concept of plant layout, types of layout; factors affecting plant layout.
Ergonomics: Ergonomic Design of equipment and work place. work station design, factors considered in designing awork station, ergonomic design standards - Study of development of stress in human body and their consequences. Case Studies.Production planning and scheduling.
Material Handling: Introduction and functions of material handling equipment, selection of material handling equipment for different requirements, safety requirements.

Recent advances in Industrial Engineering.

TEXT BOOKS

1. *Barnes, R, "Motion and Time Study" - Design and Measurement of Work . NY: John Wiley and Sons, 8th Edition, 1985.*
2. *"Introduction to Work Study", 4ed, International Labor Office, Geneva, 2006.*

REFERENCE BOOKS

1. *Martand T. Telsang, 'Industrial Engineering and Production Management' S Chand; 2nd Rev Edn 2006.*
2. *Mahajan M., "Industrial Engineering and Production Management" Dhanpat rai and Sons Publishers, 2005.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continues Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MEE323	MANAGERIAL STATISTICS	L-T-P-C: 3-0-0-3

Course Objective

To impart the knowledge of basic statistical tools for analysis and interpretation of qualitative and quantitativedata for decision making

Course Outcomes

CO1: Apply basic probability and statistics concepts for various business problems
CO2: Perform test of hypothesis
CO3: Compute and interpret the result of regression and correlation analysis for forecasting
CO4: Solve real time problems by applying different decision making methods.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		2	2						2	2	3		
CO2	3	3		2	2						2	2	3		
CO3	3	3		2	2						2	2	3		
CO4	3	3		2	2						2	2	3		

Syllabus Unit

1
Quantitative methods: Basic terminology in probability, probability rules, conditions of statistical dependence and independence, Bayes Theorem, Discrete Random Variables review of probability distributions, measure of central tendency.
Sampling and sampling distributions: Introduction to sampling, random sampling, design of experiments, introduction to sampling distributions
Estimation: point estimates, interval estimates and confidence intervals, calculating interval estimates of mean from large samples, using t test, sample size estimation**.**

Unit 2
Testing hypothesis: Introduction, basic concepts, testing hypothesis, testing when population standard deviation isknown and not known, two sample tests.
Chi-square and analysis of variance: introduction, goodness of fit, analysis of variance, inferences about a population variation

Unit 3
Regression and correlation: Estimation using regression line, correlation analysis, finding multiple regression equation, modelling techniques,
Non parametric methods and time series and forecasting: Sign test for paired data, rank sum test, rank correlation, Kolmogrov – smirnov test, variations in time series, trend analysis, cyclic variation, seasonal variation and irregular variation. Decision theory**:** Decision tree analysis

TEXT BOOKS

1. *Levin R. I. and Rubin D. S. - 'Statistics for management' - Pearson Education – 2007 - 5th Edition*
2. *Montgomery D. C. and Runger G. C. - 'Applied Statistics and Probability for Engineers' - John Wiley & Sons - 2002 - 3rd Edition*

REFERENCE BOOKS

1. *Bain.L. J. and Engelhardt M. - 'Introduction to Probability and Mathematical Statistics' - Duxbury Press -*

March 2000 - 2nd Edition

2. *Hinkelmann K. and Kempthorne O. - 'Design and Analysis of Experiments : Volume I' - John Wiley & Sons, Inc. - December 2007 - 2nd Edition*
3. *Johnson R. A. and Wichern D. W. - 'Applied Multivariate Statistical Analysis' - Prentice-Hall, Inc. - December 2001 - 5th Edition*
4. *Myers R. H. - 'Classical and Modern Regression with Applications' - PWS-Kent Publishing Company - March 2000 - 2nd Edition*
5. *Devore J. L. - 'Probability and Statistics for Engineering and the Sciences' - Brooks/Cole Publishing Company - December 1999 - 5th Edition*
6. *Freund J. E. and Walpole R. E. - 'Mathematical Statistics' - Prentice-Hall Inc. - October 1986 - 4th Edition*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MEE323	TOTAL QUALITY MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objective

To impart knowledge on quality management principles, tools, techniques and quality standards for real lifeapplications

Course Outcomes

CO1: Evaluate the principles of quality management and to explain how these principles can be applied within quality management systems.
CO2: Evaluate the performance measures using various quality and management tools
CO3: Apply the Quality Function Deployment, Taguchi principles, Total Productive Maintenance and Failure Mode and Effect Analysis concepts to solve industrial problems.
CO4: Practice the various quality system in industry.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2										2	2		
CO2	1	2										2	2		
CO3	2	2	2									2	2		
CO4	2	2	2	2								2	2		

Syllabus Unit

1
Definition of quality - dimensions of quality. Quality planning - quality costs. Total Quality Management: historical review and principles –leadership - quality council - quality statements - strategic planning - Deming philosophy.Barriers to TQM implementation

Unit 2
Customer satisfaction – Customer retention - Employee involvement - Performance appraisal - Continuous process improvement - Supplier partnership - Performance measures. Seven tools of quality.Statistical fundamentals - Control Charts for variables and attributes - Process capability - Concept of six sigma - New seven management tools - Benchmarking.

Unit 3
Quality function deployment (QFD) - Taguchi quality loss function - Total Productive Maintenance (TPM) - FMEA.Need for quality systems - ISO 9000:2000 – Elements of quality systems (such as ISO 9000:2000). Implementation of quality system – documentation - quality auditing - QS 9000-ISO 14000

TEXT BOOK

Besterfiled D. H. - 'Total Quality Management' - Pearson Education Asia – 2015-4th Edition

REFERENCE BOOKS

1. *Evans J. R, and Lidsay W. M. - 'The Management and Control of Quality' - Southwestern (Thomson Learning) - 2002 - 5th Edition*
2. *Feigenbaum A. V. - 'Total Quality Management - Vol I &II ' – McGraw Hill - 1991*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MEE324	LEAN MANUFACTURING	L-T-P-C: 3-0-0-3

Course Objectives

- Understand Lean manufacturing principles and tools
- Inculcate the concepts of value stream mapping
- Familiarize lean implementation practices

Course Outcomes

CO1: Identify key requirements and concepts in lean manufacturing.
CO2: Initiate a continuous improvement change program in a manufacturing organization**CO3:** Analyze and improve a manufacturing system by applying lean manufacturing tools**CO4:** Build value stream map for improving the productivity
CO5: Improve productivity through lean practices

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2											2	2		
CO2	2	2	2	1					2	1		1	2		1
CO3	2	2	2	2	1				2	1		1	2	1	2
CO4	2	2	2	1	1	1	1			1		2	2	1	1
CO5	2	2	2	1	1	1	1			1		2	2	1	1

SyllabusUnit

1

Introduction to Lean and Factory Simulation: History of Lean and comparison to other methods - The 7 Wastes, their causes and the effects - An overview of Lean Principles / concepts / tools - Stockless Production.

The Tools of Lean Manufacturing: Continuous Flow – Continuous Flow Manufacturing and Standard Work Flow –5S and Pull Systems (Kanban and ConWIP systems) – Error Proofing and Set-up Reduction – Total Productive Maintenance (TPM) – Kaizen Event examples. Toyota production systems.
Ford production systems – FPS gear model

Unit 2

Value Stream Mapping – Current state: Preparation for building a Current State Value Stream Map – Building a Current State Map (principles, concepts, loops, and methodology) – Application to the factory Simulation scenario.

Unit 3

Value Stream Mapping – Future State: Key issues in building the Future State Map – Process tips in building the map and analysis of the customer loop, supplier loop, manufacturing loop and information loop – Example of completedFuture State Maps – Application to factory simulation
Implementation of lean practices - Best Practices in Lean Manufacturing.

TEXT BOOKS

1. *Womack, J.P., Jones, D.T., and Roos, D., 'The Machine that Changed the World', Simon & Schuster, New York, 2007.*
2. *Liker, J.K., 'Becoming Lean', Industrial Engineering and Management Press, 1997.*

REFERENCES BOOKS

1. *Womack, J.P. and Jones, D.T., 'Lean thinking', Simon & Schuster, USA, 2003.*
2. *Rother, M. and Shook, J., 'Learning to see', The Lean Enterprise Institute, Brookline, USA, 2003.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23CSE321	SOFTWARE PROJECT MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objectives

- This course describes the key aspects of a software project.
- It introduces the basic principles of Engineering Software Projects. Most, if not all, students' complete projects as part of assignments in various courses undertaken. These projects range in size, subject and complexity but there are basic project essentials that need to be understood and practiced for successful team project outcomes.
- The course provides an understanding of the purpose, methods and benefits of process management by exposing the student to the concepts, practices, processes, tools and techniques used in process management for software development.

Course Outcomes

CO 1: To understand the basic concepts, terminologies and issues of software project management.

CO 2: To apply appropriate methods and models for the development of solutions.

CO 3: To analyze the cost-benefits of calculations so as to optimize the selection strategy**CO 4:** To evaluate methods, models and technologies towards achieving project success**CO 5:** To design and evaluate network planning models with criticality

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1								1		3	2
CO2	3	2	3						3	3		2	3	2
CO3	3	2	2	3	2	2	2	2	3	3	2	2	3	2
CO4	2	2	2	1	3	2	2	2	3	3		2	3	2
CO5	3	2	3	3	3	2	2	2	3	3		2	3	2

SyllabusUnit

1

Introduction to Software Project Management- Software Projects - ways of categorizing software projects – problems with software projects - Project Life Cycle– Management -Setting objectives –Stakeholders - Project Team- Step-wise : An overview of project planning -project Evaluation –Selection Of Appropriate Project Objectives- Software Effort Estimation Techniques, Function Point Analysis-Object Point-COCOMO.

Unit 2

Activity planning-- project schedules - sequencing and scheduling projects - Network planning model – AON andAOA- identifying critical activities-Crashing And Fast Tracking-,Risk management—Categories , Risk planning, Management and Control - Evaluating risks to the schedule. PERT- Resource Allocation, Monitoring and Tracking -Monitoring and control - allocation - identifying resource requirements - scheduling resources - creating critical paths - publishing schedule - cost schedules- sequence schedule.

Unit 3

Monitoring and control – Visualizing Progress, Earned value analysis, managing people and organizing teams-organizational structures- Planning for small projects. Case Study: PMBOK , Agile Development

TEXT BOOK(S)

Mike Cotterell, Bob Hughes. Software Project Management, Fifth Edition, Tata McGraw-Hill; 2012.

REFERENCE(S)

1. *Roger S. Pressman. Software Engineering – A Practioner's Approach, Eighth Edition, Tata McGraw-Hill publishers; 2014.*
2. *Jalote P. Software Project Management in practice, Second edition, Person Education; 2003.*

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CSE322	FINANCIAL ENGINEERING	L-T-P-C: 3-0-0-3

Pre-Requisite(s): 19MAT112 Linear Algebra, 19MAT205 Probability and Random Processes

Course Objectives

- This course serves as an introduction to financial engineering including cash flows, financial decision making etc
- It gives a thorough yet highly accessible mathematical coverage of standard and recent topics of introductory investments: fixed-income securities, modern portfolio theory, optimal portfolio growth and valuation of multi-period risky investments.

Course Outcomes

CO1: Apply basic concepts to understand and evaluate cash flows
CO2: Evaluate and arrive at a financial investment decision employing the underlying knowledge of stocks and derivatives
CO3: Analyse and design Portfolio selection methods
CO4: Understand capital market theory for stock performance evaluation

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1			2								3	2
CO2	2	3	1										3	2
CO3	1	3			2								3	2
CO4	2	1											3	2

Syllabus Unit

1
Cash Flows and Fixed income securities: Investments and markets - Principal and interest - Present and future valuesof streams - IRR. Fixed income securities - Market value for future cash - Bond value - Bond details – Yields – Convexity – Duration - Immunization. Bond portfolio management - Level of market interest rates, Term structureof interest-rate theories.

Unit 2
Stocks and Derivatives: Common stock valuation - Present value of cash dividends - Earnings approach - Value versus price - Efficient markets theory - Technical analysis. Analysis of financial statements. Derivatives - futures and options - Black Scholes formula - Utility functions - Applications in financial decision making.

Unit 3
Portfolio analysis and capital market theory: Covariance of returns – Correlation - Portfolio return - Portfolio standard deviation - Two asset case - Efficient frontier - Optimum portfolio. Capital market theory - Capital market line - Sample diversifications to reduce risk - Characteristic line - Capital asset pricing model. Arbitrage price theory - Stock performance evaluation.

TEXT BOOK(S)
1. *David Luenberger, Investment Science. Second Edition, Oxford University Press; 2013*
2. *Jack Clark Francis, Richard W. Taylor. Investments, Schaum's Outlines, Tata McGraw Hill ;2006.*

REFERENCE(S)

1. Lyuu YD. Financial Engineering and Computation. Cambridge University Press; 2004.
2. Perry H. Beaumont. Financial Engineering Principles. John Wiley and Sons Inc, New Jersey; 2004.

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CSE323	ENGINEERING ECONOMIC ANALYSIS	L-T-P-C: 3-0-0-3

Course Objectives

- Prepare engineering students to analyze and understand the business, impact of economic environment on business decisions

Course Outcomes

CO1: Understand and evaluate the economic theories, cost concepts and pricing policies and draw inferences for the investment decisions for appraisal and profitability
CO2: Appraise the dynamics of the market and market structures and portray implication for profit and revenue maximization
CO3: Employ operations research and allied techniques in managerial economics for an enhanced analysis and decision making

CO-PO Mapping

PO/ PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	2		2		2			3	2	3	2
CO2	1	3	2	1		2		2			3	2	3	2
CO3	2	3	2	2		2		2			3	2	3	2

SyllabusUnit

1

Economics: Nature and scope of managerial economics. Economic theory and managerial economics, Cost Concepts: Types of costs - Cost functions. Cost controls: reduction – Tools & Areas. Pricing policies- methods. Capital budgeting - cost of capital. Appraising project profitability

Unit 2

The essentials of demand and supply: The law of demand. Market demand curve. Other determinants of market demand. The law of supply. Determinants of market supply. The market mechanism. Price elasticity of demand, Profit and revenue maximization: Optimal input combination. Total revenue maximization.

Unit 3

Market structure: Perfect competition and monopoly. Characteristics of monopolistic competition. Oligopoly Operations Research techniques in managerial economics: Inventory models. Theory of games. Decision theory, Risk and Uncertainty, Measuring risk, Consumer behavior and risk aversion, Decision making under uncertainty with complete ignorance

TEXT BOOK(S)

Webster, T.J. Managerial Economics- Theory and Practice, Elsevier; 2004.

REFERENCE(S)

1. *Panneerselvam, R. Engineering Economics, Second Edition, PHI; 2013.*
2. *R L Varshney,K L. Maheshwari. Managerial Economics, S Chand & Sons;2014.*
3. *Harrison.B, Smith.C., and Davis.B. Introductory Economics, Second Edition, Pr Macmillan; 2013.*

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CSE324	INFORMATION SYSTEMS	L-T-P-C: 3-0-0-3

Course Objectives

- This course is to expose the students to the managerial issues relating to information systems and also understand the role of Business Process Reengineering technique in an organization.
- The course also focus on the management of information technology to provide efficiency and effectiveness or strategy decision making.

Course Outcomes

CO1: Understand the fundamental concepts of Information Systems in business.
CO2: Understand and analyse the strategic role played by Information Systems in e-commerce.
CO3: Analyse management challenges in Global Businesses predominantly dependent on IS functions.

CO-PO Mapping

PO/ PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3												3	2
CO2	2	2			2								3	2
CO3	1	3			2	2					2	1	3	2

Syllabus Unit

1

Introduction to IS -Fundamental concepts-IS in Business- Role of IS –Information system and technologies – Components of IS –resources and acivities –Types of IS- E business Applications –Role of BI and Analytics in IS- Functional Business Systems - Marketing Systems, Manufacturing systems, Human Resource Systems, Accounting Systems and Financial Management Systems.-Cross-Functional Enterprise Systems Cross-Functional Enterprise Applications, Enterprise Application Integration, Transaction Processing Systems and Enterprise Collaboration Systems. Enterprice Business Systems CRM, ERP, SCM , Case Studies

Unit 2

Electronic Commerce Systems : Scope of e-Commerce, Essential e-Commerce Processes and Electronic Payment Processes - E-commerce Applications & Issues -Decision Support Systems- Business and Decision Support, Decision Support Trends, Management Information Systems, Online Analytical Processing, Decision Support Systems, Executive Information Systems, Enterprise Portals and Decision Support - Knowledge Management Systems. Artificial Intelligence Technologies and its application in Business- Strategic role of IT- Competing with IT, valuechain ,reengineering, virtual organization ,knowledge creation-Organizational Planning, The Scenario Approach, Planning for Competitive Advantage, SWOT Business Models and Planning, Business IT Planning, -Business/ IT Strategies and Business Application Planning- Developing and Implementing Business Systems - ImplementationChallenges- barriers - change management-: Case Studies

Unit 3

Management challenges-Security, Ethical and Societal Challenges- Ethical Responsibility of Business Professionals, Computer Crime, Privacy Issues, Health Issues, and Societal Solutions- Security Management of IT- Tools of security Management, Internetworked Security Defenses, other security measures –system controls and audits- Enterprise and Global Management of IT- Managing the IS Function and Failures in IT Management - Global IT Management, Cultural, Political and Geo-economic Challenges, Global Business/IT Strategies, Global Business/IT Applications,Global IT Platforms, Global Data Access Issues and Global Systems Development –Case studies

TEXT BOOK(S)

1. *O'Brien JA, Marakas GM. Management information systems. McGraw-Hill Irwin; 2006.*
2. *Brien,Marakas G M and Behi R , MIS,9th edition, Tata McGraw Hill Special Indian Edition;2010.*

REFERENCE(S)

Laudon K, Laudon JP. Management Information Systems;2010

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

FREE ELECTIVES OFFERED UNDER HUMANITIES / SOCIAL SCIENCE STREAMSCOMMON TO ALL PROGRAMS

23CUL230	ACHIEVING EXCELLENCE IN LIFE -AN INDIAN PERSPECTIVE	L-T-P-C: 2-0-0-2

Course Objectives:

The course offers to explore the seminal thoughts that influenced the Indian Mind on the study of human possibilitiesfor manifesting excellence in life. This course presents to the students, an opportunity to study the Indian perspective of Personality Enrichment through pragmatic approach of self analysis and application.

SyllabusUnit 1

Goals of Life – Purusharthas
What are Purusharthas (Dharma, Artha, Kama, Moksha); Their relevance to Personal life; Family life; Social life & Professional life; Followed by a Goal setting workshop;
Yogic way of Achieving Life Goals – (Stress Free & Focused Life)
Introduction to Yoga and main schools of Yoga; Yogic style of Life & Time Management (Work Shop);Experiencing life through its Various Stages
Ashrama Dharma; Attitude towards life through its various stages (Teachings of Amma);

Unit 2

Personality Development
What is Personality – Five Dimensions – Pancha Kosas (Physical / Energy / Mental / Intellectual / Bliss); Stress Management & Personality; Self Control & personality; Fundamental Indian Values & Personality;
Learning Skills (Teachings of Amma)
Art of Relaxed Learning; Art of Listening; Developing 'Shraddha' – a basic qualification for obtaining Knowledge; Communication Skills - An Indian Perspective;

Unit 3

Developing Positive Attitude & Friendliness - (Vedic Perspective);
Achieving Work Excellence (Karma Yoga by Swami Vivekananda & teachings based on Amma);
Leadership Qualities – (A few Indian Role models & Indian Philosophy of Leadership);

REFERENCE BOOKS:

1. *Awaken Children (Dialogues with Sri Mata Amritanandamayi) Volumes 1 to 9*
2. *Complete works of Swami Vivekananda (Volumes 1 to 9)*
3. *Mahabharata by M. N Dutt published by Parimal publications – New Delhi (Volumes 1 to 9)*
4. *Universal message of Bhagavad-Gita (An exposition of Gita in the light of modern thought and Modern needs) by Swami Ranganathananda. (Vols.1 to 3)*
5. *Message of Upanishads, by Swami Ranaganathananda published by Bharatiya Vidya Bhavan, Bombay.*
6. *Personality Development – Swami Vivekananda published by Advaitha Ashram, Kolkatta.*
7. *Art of Man Making - Swami Chinmayananda published by Chinmaya Mission, Bombay*
8. *Will Power and its Development- Swami Budhananda published by Advaitha Ashram, Kolkatta*
9. *Ultimate Success - Swami Ramakrishnananada Puri published by Mata Amritanandamayi Math, Kollam*
10. *Yoga In Daily Life - Swami Sivananda – published by Divine Life Society*
11. *Hindu Dharma - H. H. Sri Chandrasekharandra Saraswati published by Bharatiya Vidya Bhavan, Bombay*
12. *All about Hinduism – Swami Sivananda - Published by Divine Life Society*
13. *The Mind and its Control by Swami Budhananda published by Advaitha Ashram, Kolkatta*
14. *Krida Yoga - Vivekananda Kendra, Publication.*
15. *Valmiki Ramayana – Four volumes- published by Parimal Publications, Delhi*

16. *New perspectives in Stress Management - Dr H R Nagendra & Dr R Nagaratna published by Swami Vivekananda Yoga Prakashana, Bangalore.*
17. *Mind Sound Resonance Technique (MSRT) Published by Swami Vivekananda Yoga Prakashana, Bangalore.*
18. *Yoga & Memory - Dr H R Nagendra & Dr. Shirley Telles, published by Swami Vivekananda Yoga Prakashana, Bangalore.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CUL231	EXCELLENCE IN DAILY LIFE	L-T-P-C: 2-0-0-2

Syllabus

Unit 1

1. The anatomy of 'Excellence'. What is 'excellence'? Is it judged by external factors like wealth?
2. The Great Flaw. The subject-object relationship between individual and world. Promote subject enhance excellence.
3. To work towards excellence, one must know where he is. Our present state... An introspective analysis. Our faculties within.

Unit 2

4. The play of the mind. Emotions – convert weakness into strength.
5. The indispensible role of the intellect. How to achieve and apply clear thinking?
6. The quagmire of thought.The doctrine of Karma – Law of Deservance.
7. Increase Productivity, reduce stress.. work patterning.

Unit 3

8. The art of right contact with the world. assessment, expectations.
9. Myths and Realities on key issues like richness, wisdom, spirituality.
10. Collect yourself, there is no time to waste. The blue-print of perfect action.

REFERENCES:

The Bhaja Govindam and the Bhagavad Gita.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CUL232	EXPLORING SCIENCE AND TECHNOLOGY IN ANCIENT INDIA	L-T-P-C: 2-0-0-2

OBJECTIVES:

This course offers a journey of exploration through the early developments in India of astronomy, mathematics, technologies and perspectives of the physical world. With the help of many case studies, the students will be equipped to understand concepts as well as well as actual techniques.

SyllabusUnit 1

1. General introduction: principles followed and sources;
2. Astronomy & mathematics from the Neolithic to the Indus civilization;
3. Astronomy & mathematics in Vedic literature;
4. Vedanga Jyotisha and the first Indian calendars;
5. Shulba Sutras and the foundations of Indian geometry;

Unit 2

1. Astronomy & mathematics in Jain and Buddhist literature;
2. The transition to the Siddhantic period; Aryabhata and his time;
3. The Aryabhatiya: concepts, content, commentaries;
4. Brahmagupta and his advances;
5. Other great Siddhantic savants;
6. Bhaskara II and his advances;

Unit 3

1. The Kerala school of mathematics;
2. The Kerala school of astronomy;
3. Did Indian science die out?;
4. Overview of recent Indian scientists, from S. Ramanujan onward;
5. Conclusion: assessment and discussion;

TEXTBOOK:

Indian Mathematics and Astronomy: Some Landmarks, by S. Balachandra Rao

REFERENCE:

IFIH's interactive multimedia DVD on Science & Technology in Ancient India.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CUL233	YOGA PSYCHOLOGY	L-T-P-C: 2-0-0-2

OBJECTIVES:

This course offers the foundation necessary to understand Eastern approaches to psychology and spirituality. Thecourse includes experiential components centering on meditation and spiritual practice.

SyllabusUnit 1
Introduction
Introduction to Modern Psychology
A short history of Modern Psychology - Major Schools of Modern Psychology - The three major forces in Western Psychology - Freudian Psychoanalysis; Behaviourism; Humanistic Psychology.

Introduction to Indian Psychology
What is Yoga? - Rise of Yoga Psychology tradition - Various schools of Yoga Psychology - Universal Goal of allYoga-schools.

Patanjali Yoga Sutra – 1
Introduction to Rishi Patanjali - Bird view of Yoga-Sutra - Definition of Yoga – Vrittis.

Patanjali Yoga Sutra – 2
Five Kinds of Vrittis - Pramanam - sources of right knowledge - Viparyayah – unfolded belief - Vikalpah – Unfoldedbelief - Smriti – Memory.

Unit 2
Patanjali Yoga Sutra – 3
Two formulae - Necessity of Abhyasah and Vairagyah - Foundation of Abhyasah - Foundation of Vairagyah.

Patanjali Yoga Sutra – 4
Introduction to Samadhi - Samprajnata-Samadhi - Reasoning in Samprajnata-Samadhi - Reflection in Samprajnata-Samadhi - Bliss in Samprajnata-Samadhi - Sense of Individuality in Samprajnata-Samadhi.

Patanjali Yoga Sutra – 5
Main obstacles in the path of Yoga - other obstructions - removal of obstacles by one – pointedness; by controlling Prana - by observing sense experience - by inner illumination - by detachment from matter - by knowledge of dream and sleep - by meditation as desired.

Patanjali Yoga Sutra – 6
How to make mind peaceful? - Cultivating opposite virtues: happiness – friendliness - misery – compassion - virtue – gladness - vice – indifference.

Patanjali Yoga Sutra – 7
Five causes of Pain - avidya – ignorance (Root Cause) - asmita – ‘I-Feeling’ – raga – attraction - dwesha – repulsion - abhinivesha – clinging to life.

Unit 3
Patanjali Yoga Sutra – 8
Necessity of Yoga practice - eight parts of Yoga practice - five Yamas: ahimsa – satya – asteya – brahmacharyam – aparigraha.

Patanjali Yoga Sutra – 9
Five Niyamas: Soucha – Santhosha – Tapas – Swadyah – Ishwara - Pranidhanam.

Patanjali Yoga Sutra – 10
Asanam – Pranayamah - various kinds of Pranayamah - Pratyaharah - Mastery over the senses. Report review Conclusion

REFERENCES:

1. *The course book will be "The four chapters of Freedom" written by Swami Satyananda Saraswati of Bihar School of Yoga, Munger, India.*
2. *"The message of Upanishads" written by Swami Ranganathananda. Published by Bharathiya Vidya Bhavan.*
3. *Eight Upanishads with the commentary of Sankaracharya, Translated by Swami Gambhirananda, Published by Advaita Ashram, Uttaranjal.*
4. *'Hatha Yoga Pradipika' Swami Muktibodhananda, Yoga Publications Trust, Munger, Bihar, India*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23ENG230	BUSINESS COMMUNICATION	L-T-P-C: 1-0-3-2

OBJECTIVES:

To introduce business vocabulary; to introduce business style in writing and speaking; to expose students to the cross-cultural aspects in a globalised world; to introduce the students to the art of persuasion and negotiation in business contexts.

Course Outcomes

CO1: Familiarize and use appropriate business vocabulary and etiquettes in verbal communication in the professional context
CO2: Understand organizational structures, pay structures and performance assessments
CO3: Apply language skills in drafting various business documents and other necessary communications in the business context
CO4: Understand and address cross cultural differences in the corporate environment
CO5: Participate in planned and extempore enactments of various business situations

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										3		2
CO2									1		1	
CO3										3		
CO4						2						
CO5									2			

SyllabusUnit 1
Business Vocabulary - Writing: Drafting Notices, Agenda, and Minutes - Reading: Business news, Business articles.

Unit 2
Writing: Style and vocabulary - Business Memorandum, letters, Press Releases, reports – proposals – Speaking:Conversational practice, telephonic conversations, addressing a gathering, conducting meetings.

Unit 3
Active Listening: Pronunciation – information gathering and reporting - Speaking: Cross-Cultural Issues, Group Dynamics, negotiation& persuasion techniques.

Activities
Case studies & role-plays.

BOOKS RECOMMENDED:

1. *Jones, Leo & Richard Alexander. New International Business English. CUP. 2003.*
2. *Horner, David & Peter Strutt. Words at Work. CUP. 1996.*
3. *Levi, Daniel. Group Dynamics for Teams. 3 ed. Sage Publications India Pvt. Ltd. New Delhi, 2011.*
4. *Owen, Roger. BBC Business English. BBC. 1996.*

5. *Henderson, Greta Lafollette & Price R Voiles. Business English Essentials. 7th Edition. Glencoe / McGraw Hill.*
6. *Sweeney, Simon. Communicating in Business. CUP. 2000.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23ENG231	INDIAN THOUGHT THROUGH ENGLISH	L-T-P-C: 2-0-0-2

OBJECTIVES:

To expose the students to the greatness of Indian Thought in English; to develop a sense of appreciation for the lofty Indian Thought; to develop an understanding of the eclectic Indian psyche; to develop an understanding about thesocietal changes in the recent past.

SyllabusUnit 1

Poems
Rabindranath Tagore's Gitanjali (1-10); Nizzim Ezekiel's Enterprise; A.K. Ramanujam's Small-Scale Reflections on a Great House.

Unit 2Prose
Khushwant Singh's The Portrait of a Lady; Jhumpa Lahiri's Short Story - Interpreter of Maladies.

Unit 3

Drama and Speech
Vijay Tendulkar's Silence, the Court is in Session; Motivational speeches by Jawaharlal Nehru/ S. Radhakrishnan / A. P. J. Abdul Kalam's My Vision for India etc. (any speech).

REFERENCES:

1. *Lahiri, Jhumpa. Interpreter of Maladies, Harper Collins Publications, 2000.*
2. *Ramanujan A. K. ed. K. M. George, Modern Indian Literature: An Anthology, Vol. I, Sahitya Akademi, 1992.*
3. *Singh, Khushwant. The Portrait of a Lady: Collected Stories, Penguin, 2009.*
4. *Tagore, Rabindranath. Gitanjali, Penguin Books India Pvt. Ltd, 2011.*
5. *Tendulkar, Vijay. Five Plays, Oxford University Press, 1996.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23ENG232	INSIGHTS INTO LIFE THROUGH ENGLISH LITERATURE	L-T-P-C: 2-0-0-2

OBJECTIVES:

To expose the students to different genres of Literature; to hone reading skills; to provide deeper critical and literaryinsights; to enhance creative thinking; to promote aesthetic sense.

SyllabusUnit 1

Poems
1. W. H. Auden: Refugee Blues; 2. A. K. Ramanujan: Obituary; 3. William Blake: The LittleBlack Boy; 4. Gieve Patel: Grandparents at a Family Get–together.

Unit 2

Short Stories
1. Chinua Achebe: Marriage is a Private Affair; 2. Ruskin Bond: The Thief; 3. Isai Tobolsky: Not Just Oranges; 4.K A Abbas: The Refugee

Unit 3Prose
1. A G Gardiner: On The Philosophy of Hats; 2. Robert Lynd: Mispronunciation

Practicals:

Role plays: The Proposal, Chekov / Remember Ceaser, Gordon Daviot / Final Solutions, Mahesh Dattani, Bookreviews, Movie reviews.

SUGGESTED READING:
The Old Man and the Sea, Hemingway / Any one of the novels of R.K. Narayan, etc.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23ENG233	TECHNICAL COMMUNICATION	L-T-P-C: 2-0-0-2

OBJECTIVES:

To introduce the students to the elements of technical style; to introduce the basic elements of formal correspondence; to introduce technical paper writing skills and methods of documentation; to improve oral presentation skills in formal contexts.

Course Outcomes:

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

CO1: Understand and use the basic elements of formal correspondence and methods of documentation
CO2: Learn to edit technical content for grammatical accuracy and appropriate tone and style
CO3: Use the library and internet recourses for research purposes
CO4: Demonstrate the ability to communicate effectively through group mock-technical presentations and other activities

Mapping of course outcomes with program outcomes:

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1										3				
CO2										3				
CO3				1										
CO4									3	3				

Syllabus:

Unit 1
Mechanics of writing: Grammar rules – punctuation - spelling rules - tone and style - graphical Representation.

Unit 2
Different kinds of written documents: Definitions – descriptions – instructions – recommendations - manuals -reports – proposals; Formal Correspondence: Letter Writing including job applications with Resume.

Unit 3
Technical paper writing: Library research skills - documentation style - document editing – proof reading – formatting.

Practice in oral communication and Technical presentations

REFERENCES:

1. *Hirsh, Herbert. L "Essential Communication Strategies for Scientists, Engineers and Technology Professionals". II Edition. New York: IEEE press, 2002*
2. *Anderson, Paul. V. "Technical Communication: A Reader-Centred Approach". V Edition. Harcourt Brace College Publication, 2003*
3. *Strunk, William Jr. and White. E B. "The Elements of Style" New York. Alliyan & Bacon, 1999.*
4. *Riordan, G. Daniel and Pauley E. Steven. "Technical Report Writing Today" VIII Edition (Indian Adaptation). New Delhi: Biztantra, 2004.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23ENG234	INDIAN SHORT STORIES IN ENGLISH	L-T-P-C: 2-0-0-2

OBJECTIVES:

To help the students learn the fine art of story writing; to help them learn the techniques of story telling; to help them study fiction relating it to the socio- cultural aspects of the age; to familiarize them with different strategies of reading short stories; to make them familiar with the morals and values held in high esteem by the ideals of Indianness.

SyllabusUnit 1

Introduction: Differences between novel and short stories – origin and development of short stories - Rabindranath Tagore: Kabuliwallah; Mulk Raj Anand: The Gold Watch.

Unit 2

R. K. Narayan: Sweets for Angels; K. A. Abbas: The Refugee; Khushwant Singh: The Mark of Vishnu.

Unit 3

Masti Venkatesha Iyengar: The Curds-Seller; Manohar Malgonkar: Upper Division Love; Romila Thapar: The Spell; Premchand: The Voice of God.

TEXT:

M. G. Narasimha Murthy (ed), Famous Indian Stories. Hyderabad: Orient Black Swan, 2014

REFERENCE:

Mohan Ramanan (Ed), English and the Indian Short Story: Essays in Criticism, Hyderabad, Orient Black Swan,2000.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23FRE230	PROFICIENCY IN FRENCH LANGUAGE (LOWER)	L-T-P-C: 2-0-0-2

SyllabusUnit 1

Population - Identity
How to introduce yourself (name, age, address, profession, nationality); Numbers; How to ask questions; Grammar – Pronouns - subjects; Regular verbs of 1st group (er) in the present; Être (to be) and avoir (to have) inthe present; Interrogative sentence; Gender of adjectives.

Unit 2

The suburbs - At the train station
Introduce someone; Buy a train ticket or a cinema ticket; Ask for information; Official time; Ask for a price; Thecity (church, town hall, post office…)
Grammar – Pronouns - subjects (continuation); Gender of adjectives (continuation); Plural of nouns and adjectives; Definite and indefinite articles; Interrogative adjectives; I would like (Je voudrais).

Unit 3

Paris and the districts - Looking for a room
Locate a room and indicate the way; Make an appointment; Give a price; Ordinal numbers; Usual time; Ask for thetime.
Grammar - Imperative mode; Contracted articles (au, du, des); negation.

TEXTBOOK:
Metro St Michel - Publisher: CLE international

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23FRE231	PROFICIENCY IN FRENCH LANGUAGE (HIGHER)	L-T-P-C: 2-0-0-2

SyllabusUnit 1

The first room of a student

A party to celebrate the 1st room; Description of a room; furniture; Locate objects: prepositions (devant, derrière,dans…), Read advertisement; Appreciation (I like, I prefer,).

Grammar - Perfect past tense with avoir; Possessive adjectives (mon, ton, son…); Demonstrative adjectives (ce, cet, cette); Yes (oui, si).

Unit 2 Small jobs

Conversation on the phone; Give Time indications; Answer a job offer; Describe a job; Suggest a meeting time. Grammar - Perfect past tense with être and avoir (continuation); Possessive adjectives (notre, votre, leur); Prepositions (à, pour, avec …); Pronoun as direct object (le, la, l', les).

Unit 3

University Restaurant

Inquiry; Express an opinion; Ask questions (continuation); Food, meals, taste, preferences; Nutrition, diet, choosea menu or diet, Expression of quantities (beaucoup, peu).

Grammar - Partitif (expressing quantity) (du, de la, pas de….); Comparison (plus...que, moins….que, autant …que); Interrogation (continuation), inversion, Est-ce que, qu'est-ce que?.

TEXTBOOK:

Metro St Michel - Publisher: CLE International

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23GER230	GERMAN FOR BEGINNERS I	L-T-P-C: 2-0-0-2

Syllabus

Unit 1

Greetings; Introducing one-self (formal and informal context), saying their name, origin, living place, occupation. Numbers 1-100; Saying the telephone number. Countries and Languages.
Grammar: Structure – W - Questions and Yes/No questions and statements, personal pronouns, verb conjugations. Articles.
Vocabulary: Professions.

Unit 2

Giving the personal details. Name, age, marital status, year of birth, place of birth, etc. Numbers till 1000. Saying a year. Alphabets – spelling a word.
Filling up an application form; In the restaurant – making an order.
Grammar: Definite, indefinite and negative article in nominative. Accusative: indefinite and negative Article Vocabulary: Food items

Unit 3

Numbers above 1000. Orientation in Shopping plazas: asking the price, where do I find what, saying the opinion.Grammar: Accusative – definite article. Adjectives and plural forms. Vocabulary: Furniture and currencies.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23GER231	GERMAN FOR BEGINNERS II	L-T-P-C: 2-0-0-2

Syllabus

Unit 1

Shopping and orientation in supermarket; Conversation between the customer and salesman; Where one finds what in supermarket; Asking for requests and suggestions.

Grammar: Dative of personal pronouns. Imperative form. Vocabulary: Consumables and measurements;

Unit 2

Appointments; Work and leisure time activities; Time, weekdays, months and seasons; saying the date; fixing upan appointment.

Grammar: Model verbs; Prepositions with time and place; Ordinal numbers. Vocabulary: Leisure activities, weekdays, months and seasons.

Unit 3

Family and household; Family and relations; household and daily routine. Grammar: Possessive articles; Divisibleand indivisible verbs.
Vocabulary: Family circle; Household articles.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23GER232	PROFICIENCY IN GERMANLANGUAGE (LOWER)	L-T-P-C: 2-0-0-2

Syllabus

To have an elementary exposure to German language; specifically

1. to have some ability to understand simple spoken German, and to be able to speak it so as to be able to carry on life in Germany without much difficulty (to be able to do shopping, etc.);
2. to be able to understand simple texts, and simple forms of written communication;
3. to have a basic knowledge of German grammar;
4. to acquire a basic vocabulary of 500 words;
5. to be able to translate simple letters with the use of a dictionary; and
6. to have some familiarity with the German life and culture.

(This will not be covered as part of the regular classroom teaching; this is to be acquired by self-study.)Some

useful websites will be given.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23GER233	PROFICIENCY IN GERMAN LANGUAGE (HIGHER)	L-T-P-C: 2-0-0-2

Syllabus

The basic vocabulary and grammar learned in the earlier course is mostly still passive knowledge. The endeavourof this course is to activate this knowledge and develop the skill of communication.

Topics are: Airport, railway station, travelling; shopping; invitations, meals, meeting people; around the house; the human body; colours; professions.

Past and future tenses will be introduced. Applying genitive, dative and accusative. Some German culture. Films.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HIN230	HINDI I	L-T-P-C: 2-0-0-2

OBJECTIVES:

To teach Hindi for effective communication in different spheres of life - Social context, Education, governance, Media, Business, Profession and Mass communication.

Course Outcomes:

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

CO1: Gain knowledge about the nature and culture of Hindi language
CO2: Understand the structural aspects of Hindi language
CO3: Apply the knowledge of the grammatical structures to communicate in Hindi
CO4: Analyse the social significance of modern literature.
CO5: Develop the ability to translate a given text to Hindi

CO-PO Mapping:

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1									2	3				
CO2									2	3				
CO3									2	3				
CO4										3				
CO5									2					

SyllabusUnit 1
Introduction to Hindi Language, National Language, Official Language, link Language etc. Introduction to Hindi language, Devanagari script and Hindi alphabet.

Shabda Bhed, Roopanthar ki Drishti se- Bhasha – Paribhasha aur Bhed – Sangya - Paribhasha Aur Bhed - Sangyake Roopanthar - kriya.

Unit 2
Common errors and error corrections in Parts of Speech with emphasis on use of pronouns, Adjective and verb indifferent tenses – Special usage of adverbs, changing voice and conjunctions in sentences, gender& number - General vocabulary for conversations in given context –understanding proper pronunciation - Conversations, Interviews, Short speeches.

Unit 3
Poems – Kabir 1st 8 Dohas, Surdas 1st 1 Pada; Tulsidas 1st 1 Pada; Meera 1st 1 Pada

Unit 4
Letter writing – personal and Formal – Translation from English to Hindi.

Unit 5
Kahani – Premchand: Kafan, Abhilasha, Vidroh, Poos ki rath, Juloos.

BOOKS:

1. *Prem Chand Ki Srvashrestha Kahaniyam: Prem Chand; Diamond Pub Ltd. New Delhi*
2. *Vyavaharik Hindi Vyakaran ,Anuvad thaha Rachana : Dr. H. Parameswaran, Radhakrishna publishing House, New Delhi*
3. *Kamtha Prasad Guru : Hindi Vyakaran, Best Book pub House, New Delhi*
4. *Poetry : Kavya Ras - Ed: T.V. Basker - Pachouri Press; Mathura*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HIN231	HINDI II	L-T-P-C: 2-0-0-2

OBJECTIVES:

Appreciation and assimilation of Hindi Literature both drisya & shravya using the best specimens provided as anthology.

Course Outcomes:

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

CO1: Understand the grammatical structures of Hindi CO2: Understand the post modern trends of literature CO3: Enhance critical thinking and writing skills
CO4: Identify and analyse different literary and audio-visual material
CO5: Apply fundamental knowledge of Hindi in formal and informal writing

CO-PO Mapping:

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1									**1**	**2**				
CO2									**1**	**2**				
CO3									**1**	**2**				
CO4										**3**				
CO5									**1**	**2**				

Syllabus:

Unit 1
Kavya Tarang; Dhumil ke Anthim Kavitha [Poet-Dhumil]; Dhabba [Poet-Kedarnath Singh]; Proxy [Poet-Venugopal]; Vakth [Poet-Arun Kamal]; Maachis [Poet-Suneeta Jain].

Unit 2
Communicative Hindi - Moukhik Abhivyakthi

Unit 3
Audio-Visual Media in Hindi – Movies like Tare Zameen par, Paa, Black etc., appreciation and evaluation. Newsreading and presentations in Radio and TV channels in Hindi.

Unit 4
Gadya Manjusha – Budhapa, Kheesa, Sadachar ka Thavis

Unit 5
Translation: Theory and Practice - Letter writing: Formal and Personal – Introduction to Hindi Software.

BOOKS:

1. *Kavay Tarang: Dr. Niranjan, Jawahar Pusthakalay, Mathura.*

2. *Gadya Manjusha: Editor: Govind, Jawahar Pusthakalay, Mathura*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM230	EMOTIONAL INTELLIGENCE	L-T-P-C: 2-0-0-2

Syllabus

Unit 1

Emotional Intelligence: Concept of Emotional Intelligence, Understanding the history and origin of Emotional Intelligence, Contributors to Emotional Intelligence, Science of Emotional Intelligence, EQ and IQ, Scope of Emotional Intelligence.

Unit 2

Components of Emotional Intelligence: Self-awareness, Self-regulation, Motivation, Empathy, Social skills. Emotional Intelligence Competencies, Elements of Emotional Intelligence, Models of Emotional Intelligence: The Ability-based Model, The Trait Model of Emotional Intelligence, Mixed Models of Emotional Intelligence.

Unit 3

Emotional Intelligence at Work place: Importance of Emotional Intelligence at Work place? Cost–savings of Emotional Intelligence, Emotionally Intelligent Leaders, Case Studies Measuring Emotional Intelligence: Emotionally Intelligence Tests, Research on Emotional Intelligence, Developing Emotional Intelligence.

REFERENCES:

1. *Daniel Goleman (1996). Emotional Intelligence- Why it can Matter More than IQ. Bantam Doubleday Dell Publishing Group*
2. *Daniel Goleman (2000). Working with Emotional Intelligence. Bantam Doubleday Dell Publishing Group*
3. *Liz Wilson, Stephen Neale & Lisa Spencer-Arnell (2012). Emotional Intelligence Coaching. Kogan Page India Private Limited*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM231	GLIMPSES INTO THE INDAN MIND -THE GROWTH OF MODERN INDIA	L-T-P-C: 2-0-0-2

Syllabus Unit 1
Introduction
General Introduction; 'His + Story' or 'History' ?; The concepts of 'nation', 'national identity' and 'nationalism';Texts and Textualities: Comparative Perspectives.

Unit 2
Selected writings / selections from the complete works of the following authors will be taken up for study in a chronological order:
Raja Ram Mohan Roy; Dayananda Saraswati; Bal Gangadhar Tilak; Rabindranath Tagore;

Unit 3
Selected writings / selections from the complete works of the following authors will be taken up for study in a chronological order:
Swami Vivekananda; Sri Aurobindo; Ananda K. Coomaraswamy; Sister Nivedita; Mahatma Gandhi; JawaharlalNehru; B.R. Ambedkar; Sri Chandrasekharendra Saraswati, the Paramacharya of Kanchi; Dharampal; Raja Rao; V.S. Naipaul.

Conclusion.

REFERENCES:

1. *Tilak, Bal Gangadhar. The Orion / Arctic Home in the Vedas.*
2. *Tagore, Rabindranath. The History of Bharatavarsha / On Nationalism / Greater India.*
3. *Vivekananda, Swami. "Address at the Parliament of Religions"/"The Future of India"/"In Defence of Hinduism" from Selections from the Complete Works of Swami Vivekananda.*
4. *Aurobindo, Sri. The Renaissance in India / On Nationalism.*
5. *Coomaraswamy, Ananda K. Essays in Indian Idealism (any one essay) / Dance of Shiva.*
6. *Nivedita, Sister. "Noblesse Oblige: A Study of Indian Caste" / "The Eastern Mother" from The Web of Indian Life.*
7. *Gandhi, Mahatma. Hind Swaraj.*
8. *Nehru, Jawaharlal. "The Quest" from Discovery of India.*
9. *Ambedkar, B. R. "Buddha and His Dhamma" from Collected Works.*
10. *Saraswati, Chandrasekharendra. "The Sastras and Modern Life" from The Hindu Dharma.*
11. *Dharampal. Bharatiya Chitta, Manas and Kala / Understanding Gandhi.*
12. *Naipaul, V. S. India: A Wounded Civilization / India: A Million Mutinies Now.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM232	GLIMPSES OF ETERNAL INDIA	L-T-P-C: 2-0-0-2

Syllabus

Unit 1

Introduction

A peep into India's glorious past

Ancient India – the vedas, the vedic society and the Sanatana Dharma – rajamandala and the Cakravartins – Ramarajya – Yudhisthira's ramarajya; Sarasvati - Sindhu Civilization and the myth of the Aryan Invasion; Classical India – Dharma as the bedrock of Indian society – Vaidika Brahmanya Dharma and the rise of Jainism and Buddhism – the sixteen Mahajanapadas and the beginning of Magadhan paramountcy - Kautilya and his Arthasastra – Chandragupta Maurya and the rise of the Mauryan empire – Gupta dynasty Indian art and architecture – classicalsanskrit literature – Harsavardhana; Trade and commerce in classical and medieval India and the story of Indiansupremacy in the Indian ocean region; The coming of Islam – dismantling of the traditional Indian polity – the Mughal empire – Vijayanagara samrajya and days of Maratha supremacy.

Unit 2

India's contribution to the world: spirituality, philosophy and sciences

Indian Philosophy – the orthodox (Vaidika) and the heterodox (atheistic) schools; Ramayana and Mahabharata; Bhagavad Gita; Saints and sages of India; Ancient Indian medicine: towards an unbiased perspective; Ancient Indian mathematics; Ancient Indian astronomy; Ancient Indian science and technology.

The arrival of Europeans, British paramountcy and colonization

What attracted the rest of the world to India?; India on the eve of the arrival of European merchants; The story of colonization and the havoc it wrecked on Indian culture and civilization; Macaulay and the start of the distortion ofIndian education and history; Indian economy – before and after colonization: a brief survey; The emergence ofmodern India.

Unit 3

Women in Indian society

The role and position of women in Hindu civilization; Gleanings from the Vedas, Brihadarnyaka Upanishad, Saptasati Devi Mahatmyam, Ramayana, Mahabharata, Manusmriti, Kautilya's Arthasastra and Mrichchhakatikamof Sudraka; The role and position of Indian women vis-a-vis Islam and European cultures; The great women of India.

Modern India

The national movement for freedom and social emancipation; Swami Vivekananda, Sri Aurobindo, RabindranathTagore; Understanding Mahatma Gandhi; A new nation is born as a republic – the pangs of birth and growth; India since Independence – the saga of socio-political movements; Problems facing the nation today; Globalization and Indian Economy; Bharatavarsha today and the way ahead: Regeneration of Indian National Resources.

Conclusion

The Wonder that was India; The 'politics' and 'purpose' of studying India.

REFERENCES:

1. *Parameswaran, S. The Golden Age of Indian Mathematics. Kochi: Swadeshi Science Movement.*
2. *Somayaji, D. A. A Critical Study of Ancient Hindu Astronomy. Dharwar: 1972.*
3. *Sen, S. N. & K. V. Sarma eds. A History of Indian Astronomy. New Delhi, 1985.*
4. *Rao, S. Balachandra. Indian Astronomy: An Introduction. Hyderabad: Universities Press, 2000.*
5. *Bose, D. M. et. al. A Concise History of Science in India. New Delhi: 1971.*
6. *Bajaj, Jitendra & M. D. Srinivas. Indian Economy and Polity. Chennai: Centre for Policy Studies.*
7. *Bajaj, Jitendra & M. D. Srinivas.Timeless India, Resurgent India. Chennai: Centre for Policy Studies.*
8. *Joshi, Murli Manohar. Science, Sustainability and Indian National Resurgence. Chennai: Centre for Policy Studies, 2008.*
9. *The Cultural Heritage of India. Kolkata: Ramakrishna Mission Institute of Culture.*

10. *Vivekananda, Swami. Selections from the Complete Works of Swami Vivekananda. Kolkata: Advaita Ashrama.*
11. *Mahadevan, T. M. P. Invitations to Indian Philosophy. Madras: University of Madras.*
12. *Hiriyanna, M. Outlines of Indian Philosophy. Motilal Banarsidass.*
13. *Tagore, Rabindranath. The History of Bharatavarsha / On Nationalism / Greater India.*
14. *Majumdar, R. C. et. al. An Advanced History of India. Macmillan.*
15. *Mahajan, V. D. India Since 1526. New Delhi: S. Chand & Company.*
16. *Durant, Will. The Case for India. Bangalore: Strand Book Stall, 2008.*
17. *Aurobindo, Sri. The Indian Renaissance / India's Rebirth / On Nationalism.*
18. *Nivedita, Sister. The Web of Indian Life. Kolkata: Advaita Ashrama.*
19. *Durant, Will. The Story of Civilization. Volume 1 – Our Oriental Heritage. New York: Simon & Schuster.*
20. *Ranganathananda, Swami. Eternal Values for A Changing Society. Bombay: Bharatiya Vidya Bhavan.*
21. *Ranganathananda, Swami. Universal Message of the Bhagavad Gita. Kolkata: Advaita Ashrama.*
22. *Seturaman, V. S. Indian Aesthetics. Macmillan.*
23. *Coomaraswamy, Ananda K. The Dance of Shiva. New Delhi: Sagar Publications.*
24. *Coomaraswamy, Ananda K. Essays on Indian Idealism. New Delhi: Munshiram Manoharlal.*
25. *Danino, Michel. The Invasion That Never Was.*
26. *Kautilya. Arthasastra.*
27. *Altekar, A. S. State and Government in Ancient India. New Delhi: Motilal Banarsidass.*
28. *Altekar, A. S. The Position of Women in Hindu Civilization. New Delhi: Motilal Banarsidass.*
29. *Sircar, D. C. Studies in the Religious Life of Ancient and Medieval India. New Delhi: Motilal Banarsidass.*
30. *Sircar, D. C. Studies in the Political and Administrative Systems in Ancient and Medieval Times.New Delhi: Motilal Banarsidass.*
31. *Madhavananda, Swami & R. C. Majumdar eds. The Great Women of India. Kolkata: Advaita Ashrama.*
32. *Dutt, R. C. The Economic History of India. London, 1902.*
33. *Dharampal. Collected Works.*
34. *Dharampal. Archival Compilations (unpublished)*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM233	GLIMPSES OF INDIAN ECONOMY AND POLITY	L-T-P-C: 2-0-0-2

Syllabus

Unit 1

Introduction

General Introduction; Primitive man and his modes of exchange – barter system; Prehistoric and proto-historicpolity and social organization.

Ancient India – up to 600 B.C.

Early India – the vedic society – the varnashramadharma – socio-political structure of the various institutions based on the four purusarthas; The structure of ancient Indian polity – Rajamandala and Cakravartins – Prajamandala; Socio-economic elements from the two great Epics – Ramayana and Mahabharata – the concept of the ideal King(Sri Rama) and the ideal state (Ramarajya) – Yudhisthira's ramarajya; Sarasvati - Sindhu civilization and India'strade links with other ancient civilizations; Towards chiefdoms and kingdoms – transformation of the polity: kingship – from gopati to bhupati; The mahajanapadas and the emergence of the srenis – states and cities of theIndo-Gangetic plain.

Unit 2

Classical India: 600B.C. – 1200 A.D.

The rise of Magadha, emergence of new religions – Buddhism and Jainism – and the resultant socio-economic impact; The emergence of the empire – the Mauryan Economy and Kautilya's Arthasastra; of Politics and trade –the rise of the Mercantile Community; Elements from the age of the Kushanas and the Great Guptas; India's maritime trade; Dharma at the bedrock of Indian polity – the concept of Digvijaya: dharma-vijaya, lobha-vijaya and asura-vijaya; Glimpses into the south Indian economies: political economies of the peninsula – Chalukyas, Rashtrakutas and Cholas

Medieval India: 1200 A.D. – 1720 A.D.

Advent of Islam – changes in the social institutions; Medieval India – agrarian economy, non-agricultural productionand urban economy, currency system; Vijayanagara samrajya and maritime trade – the story of Indian supremacyin the Indian Ocean region; Aspects of Mughal administration and economy; The Maratha and other provincial economies.

Unit 3

Modern India: 1720 - 1947

the Indian market and economy before the arrival of the European traders; Colonisation and British supremacy (dismantling of everything that was 'traditional' or 'Indian') – British attitude towards Indian trade, commerce and economy and the resultant ruining of Indian economy and business – man-made famines – the signs of renaissance:banking and other business undertakings by the natives (the members of the early Tagore family, the merchants ofSurat and Porbander, businessmen of Bombay, etc. may be referred to here) – the evolution of the modern bankingsystem; Glimpses into British administration of India and administrative models; The National movement and nationalist undertakings in business and industry: the Tatas and the Birlas; Modern India: the growth of large- scale industry – irrigation and railways – money and credit – foreign trade; Towards partition – birth of two new nations
– division of property; The writing of the Indian Constitution – India becomes a democratic republic – a new polity is in place.

Independent India – from 1947

India since Independence – the saga of socio-political movements; Indian economy since Independence – the fiscal system – the five year plans – liberalisation – the GATT and after; Globalisation and Indian economy; Impact ofscience and (new/ emerging) technology on Indian economy; Histories of select Indian business houses and business entrepreneurship.
Conclusion

REFERENCES:

1. *The Cultural Heritage of India. Kolkata: Ramakrishna Mission Institute of Culture.*
   Kautilya. Arthasastra.

2. *Altekar, A. S. State and Government in Ancient India. New Delhi: Motilal Banarsidass.*
3. *Sircar, D. C. Studies in the Political and Administrative Systems in Ancient and Medieval Times. New Delhi: Motilal Banarsidass.*
4. *Dutt, R. C. The Economic History of India. London, 1902.*
5. *Dharampal. Collected Works (Volumes IV & V).*
6. *Dharampal. Archival Compilations (unpublished).*
7. *Bajaj, Jitendra & M. D. Srinivas. Indian Economy and Polity. Chennai: Centre for Policy Studies.*
8. *Bajaj, Jitendra & M. D. Srinivas. Timeless India, Resurgent India. Chennai: Centre for Policy Studies.*
9. *Joshi, Murli Manohar. Science, Sustainability and Indian National Resurgence. Chennai: Centre for Policy Studies, 2008.*
10. *Tripathi, Dwijendra. The Oxford History of Indian Business. New Delhi: Oxford University Press, 2004.*
11. *McGuire, John, et al, eds. Evolution of World Economy, Precious Metals and India. New Delhi: Oxford University Press, 2001.*
12. *Tripathi, Dwijendra and Jyoti Jumani. The Concise Oxford History of Indian Business. New Delhi: Oxford University Press, 2007.*
13. *Kudaisya, Medha M. The Life and Times of G. D. Birla. New Delhi: Oxford University Press, 2003.*
14. *Raychaudhuri, Tapan and Irfan Haib, eds. The Cambridge Economic History of India. Volume*
15. *New Delhi: Orient Longman, 2004.*
16. *Kumar, Dharma, ed. The Cambridge Economic History of India. Volume 2. New Delhi: Orient Longman, 2005.*
17. *Sabavala, S. A. and R. M. Lala, eds. J. R. D. Tata: Keynote. New Delhi: Rupa & Co., 2004.*
18. *Mambro, Arvind ed. J. R. D. Tata: Letters. New Delhi: Rupa & Co., 2004.*
19. *Lala, R. M., For the Love of India: The Life and Times of Jamsetji Tata. New Delhi: Penguin, 2006.*
20. *Thapar, Romila. The Penguin History of Early India: From the Origins to AD 1300. New Delhi Penguin, 2002.*
21. *Majumdar, R. C., et. al. An Advanced History of India. Macmillan.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM234	HEALTH AND LIFESTYLE	L-T-P-C: 2-0-0-2

SyllabusUnit 1

Introduction to Health

Health is wealth; Role of lifestyle habits on health; Importance of adolescence; Stages, Characteristics and changes during adolescence; Nutritional needs during adolescence why healthy lifestyle is important for adolescence. Eating Habits - eating disorders, skipping breakfast, junk food consumption.

Practicals - Therapeutic Diets

Unit 2

Food and Nutritional Requirements during Adolescence

Fluid intake; nutrition related problems; lifestyle related problems, Role of physical activity; resting pattern andpostures, Personal habits – alcoholism, and other tobacco products, electronic addiction etc

Practicals - Ethnic Foods

Unit 3

Need for a Positive Life Style Change

Peer pressure & procrastination, Stress, depression, suicidal tendency, Mini project review and viva, Whole portions revision.

Practical - Cooking without Fire or Wire-healthy Snacks

TEXTBOOKS:

1. *B. Srilakshmi, "Dietetics", New age international (P) ltd, publishers, 2010.*
2. *"Nutrient requirement and Recommended Dietary Allowances for Indians", published by Indian Council of Medical Research, ICMR, 2010.*

REFERENCE BOOKS:

1. *K Park "Textbook of preventive and social medicine", 2010.*
2. *WHO Report on Adolescent Health: 2010*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM235	INDIAN CLASSICS FOR THE TWENTY-FIRST CENTURY	L-T-P-C: 2-0-0-2

Syllabus

Unit 1
Introductory study of the Bhagavad Gita and the Upanishads.

Unit 2
The relevance of these classics in a modern age.

Unit 3
Goals of human life - existential problems and their solutions in the light of these classics etc.

REFERENCE:
The Bhagavad Gita, Commentary by Swami Chinmayananda

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM236	INTRODUCTION TO INDIA STUDIES	L-T-P-C: 2-0-0-2

PREAMBLE:

This paper will introduce the students to the multiple dimensions of the contribution of India to the fields of philosophy, art, literature, physical and social sciences. The paper intends to give an insight to the students aboutthe far-reaching contributions of India to world culture and thought during the course of its long journey from thehoary antiquity to the present times. Every nation takes pride in its achievements and it is this sense of pride andreverence towards the achievements that lays the foundation for its all-round progress.

SyllabusUnit 1
A brief outline of Indian history from prehistoric times to the present times.

Contributions of India to world culture and civilization: Indian Philosophy and Religion; Art and Literature; Physical and Social Sciences.

Unit 2
Modern India: Challenges and Possibilities.

Scientific and technological progress in post-independence era; Socio-cultural and political movements after independence; Challenges before the nation today - unemployment – corruption – degradation of cultural and moral values - creation of a new system of education; Creation of a modern and vibrant society rooted in traditional values.

Unit 3
Modern Indian Writing in English: Trends in Contemporary Indian Literature in English.

TEXTBOOK:
Material given by the Faculty

BACKGROUND LITERATURE:

1. *Selections from The Cultural Heritage of India, 6 volumes, Ramakrishna Mission Institute of Culture (Kolkata) publication.*
2. *Selections from the Complete Works of Swami Vivekananda, Advaita Ashrama publication.*
3. *Invitations to Indian Philosophy, T. M. P. Mahadevan, University of Madras, Chennai.*
4. *Outlines of Indian Philosophy, M. Hiriyanna, MLBD.*
5. *An Advanced History of India, R. C. Majumdar et al, Macmillan.*
6. *India Since 1526, V. D. Mahajan, S. Chand & Company*
7. *The Indian Renaissance, Sri Aurobindo.*
8. *India's Rebirth, Sri Aurobindo.*
9. *On Nationalism, Sri Aurobindo.*
10. *The Story of Civilization, Volume I: Our Oriental Heritage, Will Durant, Simonand Schuster, New York.*
11. *Eternal Values for a Changing Society, Swami Ranganathananda, Bharatiya Vidya Bhavan.*
12. *Universal Message of the Bhagavad Gita, Swami Ranganathananda, Advaita Ashrama.*
13. *Awaken Children: Conversations with Mata Amritanandamayi*
14. *Indian Aesthetics, V. S. Seturaman, Macmillan.*
15. *Indian Philosophy of Beauty, T. P. Ramachandran, University of Madras, Chennai.*
16. *Web of Indian Thought, Sister Nivedita*
17. *Essays on Indian Nationalism, Anand Kumaraswamy*
18. *Comparative Aesthetics, Volume 2, Kanti Chandra Pandey, Chowkhamba, Varanasi*
19. *The Invasion That Never Was, Michel Danino*
20. *Samskara, U. R. Ananthamurthy, OUP.*
21. *Hayavadana, Girish Karnard, OUP.*

22. *Naga-Mandala, Girish Karnard, OUP.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM237	INTRODUCTION TO SANSKRIT LANGUAGE AND LITERATURE	L-T-P-C: 2-0-0-2

OBJECTIVES:

To familiarize students with Sanskrit language; to introduce students to various knowledge traditions in Sanskrit;to help students appreciate and imbibe India’s ancient culture and values.

SyllabusUnit 1

Sanskrit Language – Vakya Vyavahara - Introduction to Sanskrit language - Devanagari script and Sanskrit alphabet - Vowels and Consonants – Pronunciation - Classification of Consonants – Samyukthakshara Words – Nouns and Verbs - Cases – Introduction to Numbers and Time – Verbs: Singular, Dual and Plural – SarvaNamas: First Person, Second Person, Third Person – Tenses: Past, Present and Future -Words for Communication – Selected Slokas – MoralStories – Subhashithas – Riddles.

Unit 2

Language Studies - Role of Sanskrit in Indian & World Languages.

Unit 3

Introduction to Sanskrit Classical Literature – KavyaTradition – Drama Tradition - Stotra Tradition – Panchatantra Stories.

Unit 4

Introduction to Sanskrit Technical Literature – Astronomy – Physics – Chemistry – Botany – Engineering – Aeronautics – Ayurveda – Mathematics – Medicine – Architecture - Tradition of Indian Art – Administration –Agriculture.

Unit 5

Indology Studies – Perspectives and Innovations.

TEXTBOOKS AND REFERENCE BOOKS:

1. *Vakya Vyavahara- Prof. Vempaty Kutumba Sastri, Rashtriya Sanskrit Sansthan, New Delhi*
2. *The Wonder that is Sanskrit - Dr.Sampadananda Mishra, New Delhi*
3. *Science in Sanskrit – Samskritha Bharathi, NewDelhi*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM238	NATIONAL SERVICE SCHEME	L-T-P-C: 2-0-0-2

Syllabus

Unit 1

Introduction to Basic Concepts of NSS: History, philosophy, aims and objectives of NSS, Emblem, flag, motto,song, badge etc., Organisational structure, roles and responsibilities of various NSS functionaries.

NSS Programmes and Activities: Concept of regular activities, special campaigning, Day Camps, Basis of adoption of village / slums, methodology of conducting survey, financial pattern of the scheme, other youth programme/schemes of GOI, Coordination with different agencies, Maintenance of the Diary.

Unit 2

Volunteerism and Shramdan: Indian Tradition of volunteerism, Needs and importance of volunteerism, Motivation and Constraints of volunteerism, Shramdan as part of volunteerism, Amalabharatam Campaign, Swatch Bharath.

Unit 3

Understanding youth: Definition, profile and categories of youth, Issues, challenges and opportunities for youth, Youth as an agent of social change.

Youth and Yoga: History, philosophy and concept of Yoga, Myths and misconceptions about Yoga, Different Yoga traditions and their impacts, Yoga as a preventive and curative method, Yoga as a tool for healthy life style

Unit 4

Youth Development Programmes in India: National Youth Policy, Youth development programmes at the national level, state level and voluntary sector, youth-focused and youth-led organizations.

Youth and Crime: Sociological and psychological factors influencing youth crime, Peer mentoring in preventing crimes, Awareness about Anti-Ragging, Cyber Crime and its prevention, Juvenile Justice.

Unit 5

Environmental Issues: Environment conservation, enrichment and sustainability, climate change, waste management, rain water harvesting, energy conservation, waste land development.

Project Work / Practical

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM239	PSYCHOLOGY FOR EFFECTIVE LIVING	L-T-P-C: 2-0-0-2

Course Objectives

1. To help students acquire the basic knowledge of behavior and effective living
2. To create an awareness of the hazards of health compromising behaviours
3. To develop and strengthen the tools required to handle the adversities of life

Course Outcome

CO 1: Understand the basic concepts of Behavioral PsychologyCO 2:
Demonstrate self reflective skills through activities
CO 3: Apply the knowledge of psychology to relieve stress
CO 4: Analyse the adverse effects of health compromising behaviours.
CO 5: Evaluate and use guided techniques to overcome and cope with stress related problems.

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						1						1
CO2						2	3		3	3		
CO3						3	3	2	1		3	2
CO4						2	2	3				1
CO5						1	2				1	1

SyllabusUnit 1

Self-Awareness & Self-Motivation
Self analysis through SWOT, Johari Window, Maslow's hierarchy of motivation, importance of self esteem and enhancement of self esteem.

Unit 2

The Nature and Coping of Stress
Conflict, Relationship issues, PTSD. Stress – stressors – eustress - distress, coping with stress, stress management techniques.

Unit 3

Application of Health Psychology
Health compromising behaviours, substance abuse and addiction.

TEXTBOOKS:

1. *V. D. Swaminathan & K. V. Kaliappan "Psychology for effective living - An introduction to Health*
2. *Psychology. 2nd edition Robert J. Gatchel, Andrew Baum & David S. Krantz, McGraw Hill.*

REFERENCE BOOKS:

1. *S. Sunder, 'Textbook of Rehabilitation', 2nd edition, Jaypee Brothers, New Delhi. 2002.*
2. *Weiben & Lloyd, 'Psychology applied to Modern Life', Thompson Learning, Asia Ltd.2004.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM240	PSYCHOLOGY FOR ENGINEERS	L-T-P-C: 2-0-0-2

Course Objectives:

1. To strengthen the fundamental knowledge of human behavior
2. To strengthen the ability to understand the basic nature and behavior of humans in organizations as a whole
3. To connect the concepts of psychology to personal and professional life

Course Outcome

CO 1: Understand the fundamental processes underlying human behavior such as learning, motivation, individual differences, intelligence and personality.
CO 2: Apply the principles of psychology in day- to- day life for a better understanding of oneself and others.
CO 3: Apply the knowledge of Psychology to improve study skills and learning methods
CO 4: Apply the concepts of defense mechanisms to safeguard against abusive relationships and to nurture healthy relationships.

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						3	3		3	2		1
CO2						3	3	2	3	3	1	2
CO3										2	1	
CO4							3		2	2		2

SyllabusUnit 1
Psychology of Adolescents: Adolescence and its characteristics.

Unit 2
Learning, Memory & Study Skills: Definitions, types, principles of reinforcement, techniques for improving study skills, Mnemonics.

Unit 3
Attention & Perception: Definition, types of attention, perception.

TEXTBOOKS:

1. *S. K. Mangal, "General Psychology", Sterling Publishers Pvt. Ltd.2007*
2. *Baron A. Robert, "Psychology", Prentice Hall of India. New Delhi 2001*

REFERENCE BOOKS:

1. *Elizabeth B. Hurlock, Developmental Psychology - A life span approach, 6th edition.*
2. *Feldman, Understanding Psychology, McGraw Hill, 2000.*
3. *Clifford Morgan, Richard King, John Scholper, "Introduction to Psychology", Tata Mcgraw Hill, Pvt Ltd 2004.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM241	SCIENCE AND SOCIETY - AN INDIAN PERSPECTIVE	L-T-P-C: 2-0-0-2

Syllabus

Unit 1

Introduction

Western and Indian views of science and technology

Introduction; Francis Bacon: the first philosopher of modern science; The Indian tradition in science andtechnology: an overview.

Unit 2

Indian sciences

Introduction; Ancient Indian medicine: towards an unbiased perspective; Indian approach to logic; The methodology of Indian mathematics; Revision of the traditional Indian planetary model by Nilakantha Somasutvan in circa 1500 AD

Science and technology under the British rule

Introduction; Indian agriculture before modernization; The story of modern forestry in India; The building ofNew Delhi

Unit 3

Science and technology in Independent India

Introduction; An assessment of traditional and modern energy resources; Green revolution: a historical perspective; Impact of modernisation on milk and oilseeds economy; Planning without the spirit and thedetermination.

Building upon the Indian tradition

Introduction; Regeneration of Indian national resources; Annamahatmyam and Annam Bahu Kurvita: recollecting the classical Indian discipline of growing and sharing food in plenty and regeneration of Indian agriculture to ensure food for all in plenty.

Conclusion

REFERENCES:

1. *Joseph, George Gheverghese. The Crest of the Peacock: Non-European Roots of Mathematics. London: Penguin (UK), 2003.*
2. *Iyengar, C. N. Srinivasa. History of Hindu Mathematics. Lahore: 1935, 1938 (2 Parts).*
3. *Amma, T. A. Saraswati. Geometry in Ancient and Medieval India. Varanasi: Motilal Banarsidass, 1979.*
4. *Bag, A. K. Mathematics in Ancient and Medieval India. Varanasi: Motilal Banarsidass, 1979.*
5. *Sarma K. V. & B. V. Subbarayappa. Indian Astronomy: A Source-Book. Bombay: Nehru Centre, 1985.*
6. *Sriram, M. S. et. al. eds. 500 Years of Tantrasangraha: A Landmark in the History of Astronomy. Shimla: Indian Institute of Advanced Study, 2002.*
7. *Bajaj, Jitendra & M. D. Srinivas. Restoring the Abundance: Regeneration of Indian Agriculture to Ensure Food for All in Plenty.Shimla: Indian Institute of Advanced Study, 2001.*
8. *Bajaj, Jitendra ed. Report of the Seminar on Food for All: The Classical Indian Discipline of Growing and Sharing Food in Plenty. Chennai: Centre for Policy Studies, 2001.*
9. *Bajaj, Jitendra & M. D. Srinivas. Annam Bahu Kurvita: Recollecting the Indian Discipline of Growing and Sharing Food in Plenty. Madras: Centre for Policy Studies, 1996.*
10. *Parameswaran, S. The Golden Age of Indian Mathematics. Kochi: Swadeshi Science Movement.*
11. *Somayaji, D. A. A Critical Study of Ancient Hindu Astronomy. Dharwar: 1972.*
12. *Sen, S. N. & K. V. Sarma eds. A History of Indian Astronomy. New Delhi, 1985.*
13. *Rao, S. Balachandra. Indian Astronomy: An Introduction. Hyderabad: Universities Press, 2000.*
14. *Bose, D. M. et. al. A Concise History of Science in India. New Delhi: 1971.*
15. *Bajaj, Jitendra & M. D. Srinivas. Indian Economy and Polity. Chennai: Centre for Policy Studies.*

16. *Bajaj, Jitendra & M. D. Srinivas. Timeless India, Resurgent India. Chennai: Centre for Policy Studies.*
17. *Joshi, Murli Manohar. Science, Sustainability and Indian National Resurgence. Chennai: Centre for Policy Studies, 2008.*
18. *The Cultural Heritage of India. Kolkata: Ramakrishna Mission Institute of Culture.*

** The syllabus and the study material in use herein has been developed out of a 'summer programme' offered by the Centre for Policy Studies (CPS), Chennai at the Indian Institute of Advanced Study (IIAS), Rashtrapati Nivas, Shimla, sometime ago. The same has been very kindly made available to us by Professors Dr M.D. Srinivas (Chairman) and Dr J.K. Bajaj (Director) of the CPS.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM242	THE MESSAGE OF BHAGWAD GITA	L-T-P-C: 2-0-0-2

Syllabus

Unit 1
Introduction: Relevance of Bhagavad Gita today – Background of Mahabharatha. ArjunaVishada

Yoga: Arjuna's Anguish and Confusion – Symbolism of Arjuna's Chariot.

Sankhya Yoga: Importance of Self-knowledge – Deathlessness: Indestructibility of Consciousness – Being Established in Wisdom – Qualities of a Sthita-prajna.

Unit 2
Karma Yoga: Yoga of Action – Living in the Present – Dedicated Action without Anxiety over Results - Conceptof Swadharma.

Dhyana Yoga: Tuning the Mind – Quantity, Quality and Direction of Thoughts – Reaching Inner Silence.

Unit 3
Bhakti Yoga: Yoga of Devotion – Form and Formless Aspects of the Divine – Inner Qualities of a True Devotee.

GunatrayaVibhaga Yoga: Dynamics of the Three Gunas: Tamas, Rajas, Sattva – Going Beyond the Three Gunas – Description of a Gunatheetha.

TEXTBOOKS / REFERENCES:

1. *Swami Chinmayananda, "The Holy Geeta", Central Chinmaya Mission Trust, 2002.*
2. *Swami Chinmayananda, "A Manual of Self Unfoldment", Central Chinmaya Mission Trust, 2001.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM243	THE MESSAGE OF THE UPANISHADS	L-T-P-C: 2-0-0-2

OBJECTIVES:

To give students an introduction to the basic ideas contained in the Upanishads; and explores how their messagecan be applied in daily life for achieving excellence.

SyllabusUnit 1

An Introduction to the Principal Upanishads and the Bhagavad Gita - Inquiry into the mystery of nature - Sruti versus Smrti - Sanatana Dharma: its uniqueness - The Upanishads and Indian Culture - Upanishads and ModernScience.

Unit 2

The challenge of human experience & problems discussed in the Upanishads – the True nature of Man – theMoving power of the Spirit – The Message of Fearlessness – Universal Man - The central problems of theUpanishads – Ultimate reality – the nature of Atman - the different manifestations of consciousness.

Unit 3

Upanishad Personalities - episodes from their lives and essential teachings: Yajnavalkya, Aruni, Uddalaka, Pippalada,Satyakama Jabala, Svetaketu, Nachiketas, Upakosala, Chakrayana Ushasti, Raikva, Kapila and Janaka. Important verses from Upanishads - Discussion of Sage Pippalada's answers to the six questions in Prasnopanishad.

REFERENCES:

1. *The Message of the Upanishads by Swami Ranganathananda, Bharatiya Vidya Bhavan*
2. *Eight Upanishads with the commentary of Sankaracharya, Advaita Ashrama*
3. *Indian Philosophy by Dr. S. Radhakrishnan, Oxford University Press*
4. *Essentials of Upanishads by R L Kashyap, SAKSI, Bangalore*
5. *Upanishads in Daily Life, Sri Ramakrishna Math, Mylapore.*
6. *Eternal stories of the Upanishads by Thomas Egenes and Kumuda Reddy*
7. *Upanishad Ganga series – Chinmaya Creations*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM244	UNDERSTANDING SCIENCE OF FOOD AND NUTRITION	L-T-P-C: 2-0-0-2

Course Objectives:

- To introduce the significance of food, nutrients, locally available food resources, synergic food combinations, good cooking methods and importance of diversity in foods
- To understand nutritional imbalances and chronic diseases associated with the quality of food.
- To gain awareness about the quality of food - Organic food, genetically modified food, adulterated food, allergic food, , food poisoning and food safety.
- To understand food preservation processing, packaging and the use of additives.

Course Outcome:

CO1: Acquire knowledge about the various food and food groups

CO2: Understand nutritional imbalances and chronic diseases prevailing among different age groups.CO3: Understand the significance of safe food and apply the food safety standards

CO4: Demonstrate skills of food processing, preservation and packaging methods with or without additives CO5: Evaluate the quality of food based on the theoretical knowledge of Food and Nutrition

CO-PO Mapping:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1		1	1			1	2	1	1	1	1	3
CO 2		1	1			1	1	1	1	1	1	3
CO 3		1	1			1	1	1	1	1	1	3
CO 4		1	1			1	1	1	1	1	1	3
CO 5		1	1			1	2	1	2	1	1	3

SyllabusUnit 1

Food and Food Groups

Introduction to foods, food groups, locally available foods, Nutrients, Cooking methods, Synergy between foods, Science behind foods, Food allergies, food poisoning, food safety standards.

Cookery Practicals - Balanced Diet

Unit 2

Nutrients and Nutrition

Nutrition through life cycle, RDA, Nutrition in disease, Adulteration of foods & Food additives, Packaging and labeling of foods.

Practicals - Traditional Foods

Unit 3

Introduction to Food Biotechnology

Future foods - Organic foods and genetically modified foods, Fortification of foodsvalue addition of foods, functional foods, Nutraceuticals, supplementary foods, Processing and preservation of foods, applications of food technology in daily life, and your prospects associated with food industry – Nanoparticles, biosensors, advancedresearch.

Practicals - Value added foods

TEXTBOOKS:

1. *N. Shakuntalamanay, M. Shadaksharaswamy, "Food Facts and principles", New age international (P) ltd, publishers, 2005.*
2. *B. Srilakshmi, "Dietetics", New age international (P) ltd, publishers, 2010.*

REFERENCE BOOKS:

1. *B. Srilakshmi, "Food Science", New age international (P) ltd, publishers, 2008.*
2. *"Nutrient requirement and Recommended Dietary Allowances for Indians", published by Indian Council of Medical Research, ICMR, 2010.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23JAP230	PROFICIENCY IN JAPANESE LANGUAGE (LOWER)	L-T-P-C: 2-0-0-2

Syllabus

This paper will introduce the basics of Japanese language. Students will be taught the language through various activities like writing, reading, singing songs, showing Japanese movies etc. Moreover this paper intends to givea thorough knowledge on Japanese scripts that is Hiragana and Katakana. Classes will be conducted throughoutin Japanese class only. Students will be able to make conversations with each other in Japanese. Students can make self-introduction and will be able to write letters in Japanese. All the students will be given a text on Japanese verbs and tenses.

Students can know about the Japanese culture and the lifestyle. Calligraphy is also a part of this paper. Informal sessions will be conducted occasionally, in which students can sing Japanese songs, watch Japanese movies, do Origami – pattern making using paper.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23JAP231	PROFICIENCY IN JAPANESE LANGUAGE (HIGHER)	L-T-P-C: 2-0-0-2

Syllabus

Students will be taught the third and the most commonly used Japanese script, Kanji. Students will be taught towrite as well as speak.

Students will be given detailed lectures on Calligraphy.

This version of the course includes a new project where the students should make a short movie in Japaneselanguage selecting their own topics.

By the end of the semester they the students will master the subject in all means. They will be able to speak Japanese as fluently as they speak English. Students will be encouraged to write stories and songs in Japaneselanguage themselves.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23KAN230	KANNADA I	L-T-P-C: 2-0-0-2

OBJECTIVES:

To enable the students to acquire basic skills in functional language; to develop independent reading skills andreading for appreciating literary works; to analyse language in context to gain an understanding of vocabulary, spelling, punctuation and speech.

SyllabusUnit 1

Adalitha Kannada: bhashe, swaroopa, belavanigeya kiru parichaya Paaribhaashika padagalu
Vocabulary Building

Unit 2

Prabhandha – Vyaaghra Geethe - A. N. Murthy Rao

Prabhandha – Baredidi…baredidi, Baduku mugiyuvudilla allige…- Nemi Chandra Paragraph writing –Development: comparison, definition, cause & effect Essay – Descriptive & Narrative

Unit 3

Mochi – Bharateepriya

Mosarina Mangamma – Maasti Venkatesh Iyengar Kamalaapurada Hotelnalli – Panje Mangesh Rao Kaanike – B. M. Shree

Geleyanobbanige bareda Kaagada – Dr. G. S. Shivarudrappa Moodala Mane – Da. Ra. Bendre
Swathantryada Hanate – K. S. Nissaar Ahmed

Unit 4

Letter W riting - Personal: Congratulation, thanks giving, invitation, condolence

Unit 5

Reading Comprehension; nudigattu, gaadegalu Speaking Skills: Prepared speech, pick and speak

REFERENCES:

1. *H. S. Krishna Swami Iyangar – Adalitha Kannada – Chetana Publication, Mysuru*
2. *N. Murthy Rao – Aleyuva Mana – Kuvempu Kannada Adyayana Samste*
3. *Nemi Chandra – Badhuku Badalisabahudu – Navakarnataka Publication*
4. *Sanna Kathegalu - Prasaranga, Mysuru University , Mysuru*
5. *B. M. Shree – Kannadada Bavuta – Kannada Sahitya Parishattu*
6. *K. S. Nissar Ahmed – 75 Bhaavageetegalu – Sapna Book House (P) Ltd.*
7. *Dr. G. S. Shivarudrappa – Samagra Kavya – Kamadhenu Pustaka Bhavana*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23KAN231	KANNADA II	L-T-P-C: 2-0-0-2

OBJECTIVES:

To enable the students to acquire basic skills in functional language; to develop independent reading skills andreading for appreciating literary works; to develop functional and creative skills in language; to enable the students to plan, draft, edit & present a piece of writing.

SyllabusUnit 1
Official Correspondence: Adhikrutha patra, prakatane, manavi patra, vanijya patra

Unit 2
Nanna Hanate - Dr. G. S. Shivarudrappa
Mankuthimmana Kaggada Ayda bhagagalu – D. V. Gundappa (Padya Sankhye 5, 20, 22, 23, 25, 44, 344, 345, 346, 601)
Ella Marethiruvaga - K. S. Nissaar Ahmed Saviraru Nadigalu – S Siddalingayya

Unit 3
Sayo Aata – Da. Ra. Bendre

Unit 4
Sarva Sollegala turtu Maha Samelana - Beechi Swarthakkaagi Tyaga - Beechi

Unit 5
Essay writing: Argumentative & Analytical Précis writing

REFERENCES:

1. *H. S. Krishnaswami Iyangar – Adalitha Kannada – Chetan Publication, Mysuru*
2. *Dr. G. S. Shivarudrappa – Samagra Kavya. - Kamadhenu Pustaka Bhavana*
3. *Shrikanth - Mankuthimmana Kagga – Taatparya – Sri Ranga Printers & Binders*
4. *K. S. Nissar Ahmed – 75 Bhaavageetegalu – Sapna book house*
5. *Dr. Da. Ra. Bendre – Saayo Aata – Shri Maata Publication*
6. *Beechi – Sahukara Subbamma – Sahitya Prakashana*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23MAL230	MALAYALAM I	L-T-P-C: 2-0-0-2

Course Objectives:

To appreciate the aesthetics & cultural implications; to enhance creative thinking in mother0-tongue; to learn ourculture & values; to equip students read & write correct Malayalam; to correct the mistakes in pronunciation; to create awareness that good language is the sign of complete personality

Course Outcome:

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

CO1: Understand and inculcate philosophical thoughts and practices
CO2: Understand and appreciate the post modern trends of literature.
CO3: Analyse the literary texts and comprehend the cultural diversity of Kerala
CO4: Distinguish the different genres in Malayalam literature
CO5: Demonstrate the ability to effectively communicate in Malayalam

CO-PO Mapping:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	**2**	**3**	-	-
CO2	-	-	-	-	-	-	-	-	**2**	**3**	-	-
CO3	-	-	-	-	-	-	-	-	**2**	**3**	-	-
CO4	-	-	-	-	-	-	-	-	**-**	**3**	-	-
CO5	-	-	-	-	-	-	-	-	**1**	**1**	-	-

SyllabusUnit 1
Ancient poet trio: Adhyatmaramayanam,
Lakshmana Swanthanam (valsa soumitre… mungikidakayal), Ezhuthachan - Medieval period classics –Jnanappana (kalaminnu… vilasangalingane), Poonthanam

Unit 2
Modern Poet trio: Ente Gurunathan, Vallathol Narayana Menon - Critical analysis of the poem.

Unit 3
Short stories from period 1/2/3, Poovanpazham - Vaikaom Muhammed Basheer - Literary & Cultural figures ofKerala and about their literary contributions.

Unit 4
Literary Criticism: Ithihasa studies - Bharatha Paryadanam - Vyasante Chiri - Kuttikrishna Mararu - Outline of literary Criticism in Malayalam Literature - Introduction to Kutti Krishna Mararu & his outlook towards literature & life.

Unit 5
Error-free Malayalam: 1. Language; 2. Clarity of expression; 3. Punctuation – Thettillatha Malayalam

Writing - a. Expansion of ideas; b .Precis Writing; c. Essay Writing; d. Letter writing; e. Radio Speech; f. Script /Feature / Script Writing; g. News Editing; h. Advertising; i. Editing; j. Editorial Writing; k. Critical appreciation of literary works (Any one or two as an assignment).

REFERENCES:

1. *P. K. Balakrishnanan, Thunjan padhanangal, D. C. Books, 2007.*
2. *G. Balakrishnan Nair, Jnanappanayum Harinama Keerthanavum, N. B. S, 2005.*
3. *M. N. Karasseri, Basheerinte Poonkavanam, D. C. Books, 2008.*
4. *4 M. N. Vijayan, Marubhoomikal Pookkumbol, D. C. Books, 2010.*
5. *M. Thomas Mathew, Lavanyanubhavathinte Yukthisasthram, National Book Stall, 2009.*
6. *M. Leelavathy, Kavitha Sahityacharitram, National Book Stall, 1998.*
7. *Thayattu Sankaran, Vallathol Kavithapadhanam, D. C. Books, 2004.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23MAL231	MALAYALAM II	L-T-P-C: 2-0-0-2

OBJECTIVES:

To appreciate the aesthetics & cultural implications; to enhance creative thinking in mother-tongue; to learn ourculture & values; to equip students read & write correct Malayalam; to correct the mistakes in pronunciation; tocreate awareness that good language is the sign of complete personality.

Course Outcome:

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

CO1: Understand the different cultural influences in linguistic translation CO2: Identify and appreciate the Romantic elements of modern literature CO3: Analyze the genre of autobiographical writing
CO4: Critically evaluate the significance of historical, political and socio cultural aspects in literature CO5: Demonstrate good writing skills in Malayalam

CO-PO Mapping:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	**2**	**3**	-	-
CO2	-	-	-	-	-	-	-	-	**2**	**3**	-	-
CO3	-	-	-	-	-	-	-	-	**2**	**3**	-	-
CO4	-	-	-	-	-	-	-	-	**-**	**3**	-	-
CO5	-	-	-	-	-	-	-	-	**1**	**1**	-	-

Syllabus Unit 1

Ancient poet trio: Kalayanasougandhikam, (kallum marangalun… namukkennarika vrikodara) Kunjan Nambiar - Critical analysis of his poetry - Ancient Drama: Kerala Sakunthalam (Act 1), Kalidasan (Translated by Attor Krishna Pisharody).

Unit 2

Modern / romantic / contemporary poetry: Manaswini, Changampuzha Krishna Pillai – Romanticism – modernism.

Unit 3

Anthology of short stories from period 3/4/5: Ninte Ormmayku, M. T. Vasudevan Nair - literary contributions of his time

Unit 4

Part of an autobiography / travelogue: Kannerum Kinavum, V. T. Bhattathirippadu - Socio-cultural literature - historical importance.

Unit 5

Error-free Malayalam - 1. Language; 2. Clarity of expression; 3. Punctuation - Thettillatha Malayalam

W riting - a. Expansion of ideas; b. Précis Writing ; c. Essay Writing; d. Letter writing; e. Radio Speech; f. Script /Feature / Script Writing; g. News Editing; h. Advertising; i. Editing; j. Editorial Writing; k. Critical appreciation of literary works (Any one or two as an assignment).

REFERENCES:

1. *Narayana Pillai. P. K, Sahitya Panchanan. Vimarsanathrayam, Kerala Sahitya Academy, 2000*
2. *Sankunni Nair. M. P, Chathravum Chamaravum, D. C. Books, 2010.*
3. *Gupthan Nair. S, Asthiyude Pookkal, D. C Books. 2005*
4. *Panmana Ramachandran Nair, Thettillatha Malayalam, Sariyum thettum etc., D. C. Book, 2006.*
5. *M. Achuthan, Cherukatha-Innale, innu, National Book Stall, 1998.*
6. *N. Krishna Pillai, Kairaliyude Katha, National Book Stall, 2001.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23SAN230	SANSKRIT I	L-T-P-C: 2-0-0-2

OBJECTIVES:

To familiarize students with Sanskrit language and literature; to enable them to read and understand Sanskritverses and sentences; to help them acquire expertise for self- study of Sanskrit texts and communication in Sanskrit; to help the students imbibe values of life and Indian culture as propounded in scriptures.

SyllabusUnit 1
Introduction to Sanskrit language, Devanagari script - Vowels and consonants, pronunciation, classification of consonants, conjunct consonants, words – nouns and verbs, cases – introduction, numbers, Pronouns,communicating time in Sanskrit. Practical classes in spoken Sanskrit

Unit 2
Verbs- Singular, Dual and plural – First person, Second person, Third person. Tenses – Past, Present and Future – Atmanepadi and Parasmaipadi-karthariprayoga

Unit 3
Words for communication, slokas, moral stories, subhashithas, riddles (from the books prescribed)

Unit 4
Selected slokas from Valmiki Ramayana, Kalidasa's works and Bhagavad Gita. Ramayana – chapter VIII - verse5, Mahabharata - chapter 174, verse -16, Bhagavad Gita – chapter - IV verse 8, Kalidasa's Sakuntalam Act IV – verse 4

Unit 5
Translation of simple sentences from Sanskrit to English and vice versa.

ESSENTIAL READING:

1. *Praveshaha; Publisher: Samskrita bharati, Aksharam, 8th cross, 2nd phase, girinagar, Bangalore - 560 085*
2. *Sanskrit Reader I, II and III, R. S. Vadhyar and Sons, Kalpathi, Palakkad*
3. *Prakriya Bhashyam written and published by Fr. John Kunnappally*
4. *Sanskrit Primer by Edward Delavan Perry, published by Ginn and Company Boston*
5. *Sabdamanjari, R. S. Vadyar and Sons, Kalpathi, Palakkad*
6. *Namalinganusasanam by Amarasimha published by Travancore Sanskrit series*
7. *Subhashita Ratna Bhandakara by Kashinath Sharma, published by Nirnayasagar press*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23SAN231	SANSKRIT II	L-T-P-C: 2-0-0-2

OBJECTIVES:

To familiarize students with Sanskrit language and literature; to enable them to read and understand Sanskritverses and sentences; to help them acquire expertise for self- study of Sanskrit texts and communication in Sanskrit; to help the students imbibe values of life and Indian culture as propounded in scriptures.

SyllabusUnit 1
Seven cases, indeclinables, sentence making with indeclinables, Saptha karakas.

Unit 2
Ktavatu Pratyaya, Upasargas, Ktvanta, Tumunnanta, Lyabanta. Three Lakaras – brief introduction, Lot lakara.

Unit 3
W ords and sentences for advanced communication. Slokas, moral stories (Pancatantra) Subhashitas, riddles.

Unit 4
Introduction to classical literature, classification of Kavyas, classification of Dramas - The five Mahakavyas, selected slokas from devotional kavyas- Bhagavad Gita – chapter - II verse 47, chapter - IV verse 7, chapter -VI verse 5, chapter - VIII verse 6, chapter - XVI verse 21, Kalidasa's Sakuntala act IV – verse 4, Isavasyopanishat 1st Mantra, Mahabharata chapter 149 verses 14 - 120, Neetisara chapter - III

Unit 5
Translation of paragraphs from Sanskrit to English and vice versa.

ESSENTIAL READING:

1. *Praveshaha; Publisher: Samskrita bharati, Aksharam, 8th cross, 2nd phase, girinagar, Bangalore -560 085*
2. *Sanskrit Reader I, II and III, R.S. Vadhyar and Sons, Kalpathi, Palakkad*
3. *Prakriya Bhashyam written and published by Fr. John Kunnappally*
4. *Sanskrit Primer by Edward Delavan Perry, published by Ginn and Company Boston*
5. *Sabdamanjari, R. S. Vadyar and Sons, Kalpathi, Palakkad*
6. *Namalinganusasanam by Amarasimha published by Travancore Sanskrit series*
7. *Subhashita Ratna Bhandakara by Kashinath Sharma, published by Nirnayasagar Press.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23SWK230	CORPORATE SOCIAL RESPONSIBILITY	L-T-P-C: 2-0-0-2

Syllabus

Unit 1

Understanding CSR - Evolution, importance, relevance and justification. CSR in the Indian context, corporate strategy. CSR and Indian corporate. Structure of CSR - In the Companies Act 2013 (Section 135); Rules underSection 13; CSR activities, CSR committees, CSR policy, CSR expenditure CSR reporting.

Unit 2

CSR Practices & Policies - CSR practices in domestic and international area; Role and contributions of voluntary organizations to CSR initiatives. Policies; Preparation of CSR policy and process of policy formulation; Government expectations, roles and responsibilities. Role of implementation agency in Section 135 of the Companies Act, 2013. Effective CSR implementation.

Unit 3

Project Management in CSR initiatives - Project and programme; Monitoring and evaluation of CSR Interventions. Reporting - CSR Documentation and report writing. Reporting framework, format and procedure.

REFERENCES:

1. *Corporate Governance, Ethics and Social Responsibility, V Bala Chandran and V Chandrasekaran, PHI learning Private Limited, New Delhi 2011.*
2. *White H. (2005) Challenges in evaluating development effectiveness: Working paper 242, Institute of Development Studies, Brighton.*
3. *UNDP (nd) Governance indicators: A users guide. Oslo: UNDP*
4. *Rao, Subbha (1996) Essentials of Human Resource Management and Industrial Relations, Mumbai, Himalaya*
5. *Rao, V. S. L. (2009) Human Resource Management, New Delhi, Excel Books,*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23SWK231	WORKPLACE MENTAL HEALTH	L-T-P-C: 2-0-0-2

Syllabus

Unit 1

Mental Health – concepts, definition, Bio-psycho-social model of mental health. Mental health and mental illness, characteristics of a mentally healthy individual, Signs and symptoms of mental health issues, presentation of a mentally ill person. Work place – definition, concept, prevalence of mental health issues in the work place, why invest in workplace mental health, relationship between mental health and productivity, organizational culture and mental health. Case Study, Activity.

Unit 2

Mental Health Issues in the Workplace: Emotions, Common emotions at the workplace, Mental Health issues - Anger, Anxiety, Stress & Burnout, Depression, Addictions – Substance and Behavioural, Psychotic Disorders - Schizophrenia, Bipolar Disorder, Personality disorders. Crisis Situations - Suicidal behavior, panic attacks, reactions to traumatic events. Stigma and exclusion of affected employees. Other issues –work-life balance, Presenteeism, Harassment, Bullying, Mobbing. Mental Health First Aid - Meaning. Case Study, Activity.

Unit 3

Strategies of Help and Care: Positive impact of work on health, Characteristics of mentally healthy workplace, Employee and employer obligations, Promoting mental health and well being- corporate social responsibility (CSR), an inclusive work environment, Training and awareness raising, managing performance, inclusive recruitment, Supporting individuals-talking about mental health, making reasonable adjustments, Resources and support for employees - Employee Assistance Programme / Provider (EAP), in house counsellor, medical practitioners, online resources and telephone support, 24 hour crisis support, assistance for colleagues and care givers, Legislations. Case Study, Activity.

REFERENCES:

1. *American Psychiatric Association. "Diagnostic and statistical manual of mental disorders: DSM-IV 4th ed." www.terapiacognitiva.eu/dwl/dsm5/DSM-IV.pdf*
2. *American Psychiatric Association. (2000) www.ccsa.ca/Eng/KnowledgeCentre/OurDatabases/ Glossary/Pages/index.aspx.*
3. *Canadian Mental Health Association, Ontario "Workplace mental health promotion, A how to guide"wmhp.cmhaontario.ca/*
4. *Alberta Health Services Mental Health Promotion. (2012). Minding the Workplace: Tips for employees and managers together. Calgary: Alberta Health Services.http:// www.mentalhealthpromotion.net/resources/minding-the-workplace-tips-for-employees-and- managers-together.pdf*
5. *Government of Western Australia, Mental Health Commission. (2014) "Supporting good mental health in the work place." http://www.mentalhealth.wa.gov.au/Libraries/pdf_docs/ supporting_good_mental_health_in_the_workplace_1.sflb.ashx*
6. *Mental Health Act 1987 (India) www.tnhealth.org/mha.htm*
7. *Persons with disabilities Act 1995 (India) socialjustice.nic.in*
8. *The Factories Act 1948 (India) www.caaa.in/Image/19ulabourlawshb.pdf*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23TAM230	TAMIL I	L-T-P-C: 2-0-0-2

Course Objectives:

- To introduce the students to different literature- Sangam literature, Epics, Bhakthi literatureandmodern literature.
- To improve their ability tocommunicate with creative concepts, and also to introduce them to the usefulness of basicgrammaticalcomponents in Tamil.

Course Outcomes

CO 1: To understand the Sangam literatureCO 2:
To understand the creative literature
CO 3: To understand the literary work on religious scripturesCO 4:
To improve the communication and memory skills
CO 5: To understand the basic grammar components of Tamil language and their usage and applications.CO 6:
Understand creative writing aspects and apply them.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			-	-	-	-	-	-	2	2	-	-
CO2			-	-	-	-	-	-	2	2	-	-
CO3			-	-	-	-	-	-	2	2	-	-
CO4			-	-	-	-	-	-	2	2	-	-
CO5			-	-	-	-	-	-	2	2	-	-
CO6			-	-	-	-	-	-	2	2	-	-

SyllabusUnit1

The history ofTamilliterature: Nāṭṭupuṟap pāṭalkaḷ, kataikkaḷ, paḻamoḻikaḷ - ciṟukataikaḷ tōṟṟamum vaḷarcciyum, ciṟṟilakkiyaṅkaḷ: Kaliṅkattup paraṇi (pōrpāṭiyatu) - mukkūṭaṟ paḷḷu 35.
Kāppiyaṅkaḷ: Cilappatikāram – maṇimēkalai naṭaiyiyal āyvu maṟṟum aimperum – aiñciṟuṅ kāppiyaṅkaḷ toṭarpāṉa ceytikaḷ.

Unit 2

tiṇai ilakkiyamum nītiyilakkiyamum - patiṉeṇkīḻkkaṇakku nūlkaḷ toṭarpāṉa piṟa ceytikaḷ - tirukkuṟaḷ (aṉpu, paṇpu, kalvi, oḻukkam, naṭpu, vāymai, kēḷvi, ceynaṉṟi, periyāraittuṇakkōṭal, viḻippuṇarvu pēṉṟa atikārattil uḷḷa ceytikaḷ.
Aṟanūlkaḷ: Ulakanīti (1-5) – ēlāti (1,3,6). - Cittarkaḷ: Kaṭuveḷi cittar pāṭalkaḷ (āṉantak kaḷippu –1, 4, 6, 7, 8), maṟṟum akappēy cittar pāṭalkaḷ (1-5).

Unit 3

tamiḻ ilakkaṇam: Vākkiya vakaikaḷ – taṉviṉai piṟaviṉai – nērkkūṟṟu ayaṟkūṟṟu

Unit 4

tamil̲aka ar̲iñarkal̲in̲ tamil̲ toṇṭum camutāya toṇṭum: Pāratiyār, pāratitācan̲, paṭṭukkōṭṭai kalyāṇacuntaram, curatā, cujātā, cir̲pi, mēttā, aptul rakumān̲, na.Piccaimūrtti, akilan̲, kalki, jī.Yū.Pōp, vīramāmun̲ivar, aṇṇā, paritimār̲ kalaiñar, mar̲aimalaiyaṭikaḷ.

Unit 5

tamil̲ mol̲i āyvil kaṇin̲i payan̲pāṭu. - Karuttu parimār̲r̲am - viḷampara mol̲iyamaippu – pēccu - nāṭakam paṭaippu -cir̲ukatai, katai, putin̲am paṭaippu.

Textbooks:

1. http:/Www.tamilvu.trg/libirary/libindex.htm.
2. http:/Www.tunathamizh.tom/2013/07/blog0post_24.html
3. Mu.Varatarācan̲ “tamil̲ ilakkiya varalār̲u” cāhitya akaṭemi papḷikēṣan̲s, 2012
4. nā.Vān̲amāmalai “pal̲aṅkataikaḷum, pal̲amol̲ikaḷum” niyū ceñcuri puttaka veḷiyīṭṭakam,
5. 1980,2008
6. nā.Vān̲amāmalai, “tamil̲ar nāṭṭuppāṭalkaḷ” niyū ceñcuri puttaka veḷiyīṭṭakam 1964,2006
7. pon̲ maṇimār̲an̲ “aṭōn̲ tamil̲ ilakkaṇam “aṭōn̲ papḷiṣiṅ kurūp, vañciyūr,
8. tiruvan̲antapuram, 2007.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23TAM231	TAMIL II	L-T-P-C: 2-0-0-2

Course Objectives

- To learn the history ofTamilliterature.
- To analyze different styles of Tamil Language.
- To strengthen thecreativity in communication, Tamilbasicgrammar and use of computer on Tamil Language.

Course Outcomes

CO 1: Understand the history of Tamil literature.

CO 2: Apply practical and comparative analyses on literature.

CO 3: Understand thinai literature, literature on justice, Pathinenkeelkanaku literature.CO 4: Understand the tamil scholars' service to Tamil language and society.
CO 5: Understand components of Tamil grammar and its usageCO 6: Understand creative writing aspects and apply them

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			-	-	-	-	-	-	2	2	-	-
CO2			-	-	-	-	-	-	2	2	-	-
CO3			-	-	-	-	-	-	2	2	-	-
CO4			-	-	-	-	-	-	2	2	-	-
CO5			-	-	-	-	-	-	2	2	-	-
CO6			-	-	-	-	-	-	2	2	-	-

SyllabusUnit 1

The history ofTamilliterature: Nāṭṭupuṟap pāṭalkaḷ, kataikkaḷ, paḻamoḻikaḷ - ciṟukataikaḷ tōṟṟamum vaḷarcciyum, ciṟṟilakkiyaṅkaḷ: Kaliṅkattup paraṇi (pōrpāṭiyatu) - mukkūṭaṟ paḷḷu 35.
Kāppiyaṅkaḷ: Cilappatikāram – maṇimēkalai naṭaiyiyal āyvu maṟṟum aimperum – aiñciṟuṅ kāppiyaṅkaḷ toṭarpāṉa ceytikaḷ.

Unit 2

tiṇai ilakkiyamum nītiyilakkiyamum - patiṉeṇkīḻkkaṇakku nūlkaḷ toṭarpāṉa piṟa ceytikaḷ - tirukkuṟaḷ (aṉpu, paṇpu, kalvi, oḻukkam, naṭpu, vāymai, kēḷvi, ceynaṉṟi, periyāraittuṇakkōṭal, viḻippuṇarvu pēṉṟa atikārattil uḷḷa ceytikaḷ.
Aṟanūlkaḷ: Ulakanīti (1-5) – ēlāti (1,3,6). - Cittarkaḷ: Kaṭuveḷi cittar pāṭalkaḷ (āṉantak kaḷippu –1, 4, 6, 7, 8), maṟṟum akappēy cittar pāṭalkaḷ (1-5).

Unit 3

tamiḻ ilakkaṇam: Vākkiya vakaikaḷ – taṉviṉai piṟaviṉai – nērkkūṟṟu ayaṟkūṟṟu

Unit 4

tamiḻaka aṟiñarkaḷiṉ tamiḻ toṇṭum camutāya toṇṭum: Pāratiyār, pāratitācaṉ, paṭṭukkōṭṭai kalyāṇacuntaram, curatā, cujātā, ciṟpi, mēttā, aptul rakumāṉ, na.Piccaimūrtti, akilaṉ, kalki, jī.Yū.Pōp, vīramāmuṉivar, aṇṇā, paritimāṟ kalaiñar, maṟaimalaiyaṭikaḷ.

Unit 5

tamiḻ moḻi āyvil kaṇiṉi payaṉpāṭu. - Karuttu parimāṟṟam - viḷampara moḻiyamaippu – pēccu - nāṭakam paṭaippu -ciṟukatai, katai, putiṉam paṭaippu.

Text Books / References

http:/Www.tamilvu.trg/libirary/libindex.htm. http:/Www.tunathamizh.tom/2013/07/blog0post_24.html
Mu.Varatarācaṉ "tamiḻ ilakkiya varalāṟu" cāhitya akaṭemi papḷikēṣaṉs, 2012
nā.Vāṉamāmalai "paḻaṅkataikaḷum, paḻamoḻikaḷum" niyū ceñcuri puttaka veḷiyīṭṭakam, 1980,2008
nā.Vāṉamāmalai, "tamiḻar nāṭṭuppāṭalkaḷ" niyū ceñcuri puttaka veḷiyīṭṭakam 1964,2006 poṉ maṇimāṟaṉ "aṭōṉ tamiḻ ilakkaṇam "aṭōṉ papḷiṣiṅ kurūp, vañciyū

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.