GANDHI INSTITUTE OF TECHNOLOGY AND MANAGEMENT (GITAM)
(Deemed to be University)
VISAKHAPATNAM * HYDERABAD * BENGALURU

Accredited by NAAC with A+ Grade

CURRICULUM AND SYLLABUS

OF

B.Tech. Biotechnology

(w.e.f. 2021-22 admitted batch)

Academic Regulations

Applicable for the Undergraduate programmes in the Faculties of **Engineering, Humanities, Management and the Sciences**

https://www.gitam.edu/academic-regulations

B.Tech. Biotechnology
(Effective from the academic year 2021-22 admitted batch)

Program Educational Objectives

PO1 ENGINEERING KNOWLEDGE: Apply the knowledge of Mathematics, Science,Engineering Fundamentals, and an Engineering specialization to the solution of Complex Engineering problems.

PO2 PROBLEM ANALYSIS: Identify, formulate, research literature, and analyze Complex Engineering problems reaching substantiated conclusions using first principles of Mathematics, Natural Sciences, and Engineering Sciences.

PO3 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.

PO4 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.

PO5 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.

PO6 THE ENGINEER AND SOCIETY: Apply reasoning informed by the contextual knowledgeto assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the Professional Engineering practice.

PO7 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.

PO8 ETHICS: Apply ethical principles and commit to Professional Ethics and responsibilities and norms of the engineering practice.

PO9 INDIVIDUAL AND TEAM WORK: Function effectively as an individual, and as a memberor leader in diverse teams, and in multidisciplinary settings.

PO10 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.

PO11 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 multi-disciplinary environments.

PO12 LIFE LONG LEARNING: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

PROGRAM OUTCOMES

The students of B. Tech. Biotechnology, after completion of the program will be able to:

PO 1 Apply the principles of biotechnology

PO 2 Integrate the concepts of biotechnology in the fields of medicine and healthcare

PO 3 Implement the concepts of biotechnology in agriculture

PO 4 Introduce the concepts of biotechnology in industry and environment

PO 5 Design a pilot plant for implementing a commercial bioprocess

PO 6 Adapt to changing professional and societal needs by practicing the art of lifelong learning

PO 7 Formulate and design end-to-end solutions for biotechnology industries

PO 8 Implement ethical principles in biotechnology practices

PO 9 Manage a team of professionals in different fields of biotechnology

PO 10 Take up higher studies in core and interdisciplinary fields.

PO 11 Carry out research in the field of biotechnology and related multidisciplinary specializations.

PO 12 Become an entrepreneur and contribute to industrialization in solving problems of societal relevance

PROGRAM SPECIFIC OUTCOMES

PSO 1 Acquire knowledge on the essentials of **Biology and Chemical engineering** for laying a strong foundation to understand the emerging and advanced **engineering** concepts in Biotechnology.

PSO 2 Acquire knowledge regarding applications of **Biotechnology** for enabling their applications in industry and research

PSO 3 Acquire ability to apply **Biotechnology** to develop products with improved characteristics thereby increasing farmers' income, improving human health and decreasing environmental pollution.

Course structure of B. Tech (Biotechnology) 2021-2022 admitted batch

University Core (UC)

Course code	Level	Course title	L	T	P	S	J	C
CSEN1001	1	IT Productivity Tools^	0	0	2	0	0	1*
LANG1001	1	Communication Skills in English - Beginners	0	0	4	0	0	2*
LANG1011	1	Communication Skills in English	0	0	4	0	0	2
LANG1021	1	Advanced Communication Skills in English	0	0	4	0	0	2
CLAD1001	1	Emotional Intelligence & Reasoning Skills (Softskills 1)	0	0	2	0	0	1
CLAD1011	1	Leadership Skills & Quantitative Aptitude (Softskills 2)	0	0	2	0	0	1
CLAD1021	1	Verbal Ability & Quantitative Ability (Softskills 3)	0	0	2	0	0	1
CLAD1031	1	Practicing Verbal Ability & Quantitative Aptitude (Softskills 4)	0	0	2	0	0	1
VEDC1001	1	Venture Development	0	0	0	2	0	2
DOSP10XX	1	Sports 1#	0	0	0	2	0	2*
DOSL10XX	1	Club Activity#	0	0	0	2	0	2*
POLS1001	1	Indian Constitution and History	2	0	0	0	0	2*
PHPY1001	1	Gandhi for the 21st Century	2	0	0	0	0	2*
DOSL10XX	1	Community Service#	0	0	0	0	2	2*
ENVS1001	1	Environmental Studies^	3	0	0	0	0	3*
MFST1001	1	Health and Welbeing#	0	0	2	0	0	1*
CLAD20XX	2	Softskills 5A/5B/5C	0	0	2	0	0	1
CLAD20XX	2	Softskills 6A/6B/6C	0	0	2	0	0	1
FINA3001	3	Personal Financial Planning#	0	0	2	0	0	1*

* Pass/Fail courses
\# Opt any three courses among the five
^ Online/Swayam/NPTEL Courses

Softskills courses 5 and 6

Course code	Level	Course title	L	T	P	S	J	C
CLAD2001	2	Preparation for Campus Placement - 1 (Softskills 5A)	0	0	2	0	0	1
CLAD2011	2	Preparation For Higher Education (GRE/ GMAT) - 1 (Softskills 5B)	0	0	2	0	0	1
CLAD2021	2	Preparation for CAT/ MAT - 1 (Softskills 5C)	0	0	2	0	0	1
CLAD2031	2	Preparation For Campus Placement - 2 (Softskills 6A)	0	0	2	0	0	1
CLAD2041	2	Preparation For Higher Education (GRE/ GMAT) - 2 (Softskills 6B)	0	0	2	0	0	1
CLAD2051	2	Preparation for CAT/ MAT - 2 (Softskills 6C)	0	0	2	0	0	1

Sports courses

Course code	Level	Course title	L	T	P	S	J	C
DOSP1001	1	Badminton	0	0	0	2	0	2
DOSP1011	1	Chess	0	0	0	2	0	2
DOSP1021	1	Carrom	0	0	0	2	0	2
DOSP1031	1	Football	0	0	0	2	0	2
DOSP1041	1	Volleyball	0	0	0	2	0	2
DOSP1051	1	Kabaddi	0	0	0	2	0	2
DOSP1061	1	Kho Kho	0	0	0	2	0	2
DOSP1071	1	Table Tennis	0	0	0	2	0	2
DOSP1081	1	Handball	0	0	0	2	0	2
DOSP1091	1	Basketball	0	0	0	2	0	2
DOSP1101	1	Tennis	0	0	0	2	0	2
DOSP1111	1	Throwball	0	0	0	2	0	2

Club activity courses

Course code	Level	Course title	L	T	P	S	J	C
DOSL1001	1	Club Activity (participant)	0	0	0	2	0	2
DOSL1011	1	Club Activity (Member of club)	0	0	0	2	0	2
DOSL1021	1	Club Activity (Leader of CLub)	0	0	0	2	0	2
DOSL1031	1	Club Activity (Competitor)	0	0	0	2	0	2

Community service courses

Course code	Level	Course title	L	T	P	S	J	C
DOSL1041	1	Community Services - Volunteer	0	0	0	0	2	2
DOSL1051	1	Community Services - Mobilizer	0	0	0	0	2	2

Faculty Core (FC)

Course code	Level	Course title	L	T	P	S	J	C
PHYS1001	1	Physics	2	1	2	0	0	4
CSEN1021	1	Programming with Python	0	0	6	0	0	3
	1	Workshop	0	0	4	0	0	2
CHEM1001	1	Chemistry	2	1	2	0	0	4
	1	Basic Electrical and Electronics Engineering	2	1	2	0	0	4
MECH1011	1	Engineering Visualization and Product Realization	0	0	4	0	0	2
CSEN1011	1	Problem Solving and Programming in C	0	0	6	0	0	3
BTEN1001	1	Introduction to Mathematics-I / Introduction to Biotechnology-I	2	0	0	0	0	2
BTEN1021	1	Introduction to Mathematics-II / Introduction to Biotechnology-II	2	0	0	0	0	2
PHYS1041	2	Mechanics and Modern Physics	2	1	2	0	0	4
	2	Calculus I	2	0	0	0	0	2
	2	Calculus II	2	0	0	0	0	2
	2	Design Thinking	0	0	2	0	0	1
	2	Maths Basket 3: Differential equations	2	0	0	0	0	2
MATH1021	2	Maths Basket 4: Transform techniques	2	0	0	0	0	2
MATH1281	2	Probability and Statistics	3	0	0	0	0	3
	3	Management Basket	3	0	0	0	0	3
	3	Applications of Artificial Intelligence	0	0	2	0	0	1
	3	Universal Human Values	3	0	0	0	0	3*
	4	Capstone Project - Introduction	0	0	0	1	0	2
	4	Internship 2	0	0	0	1	0	3
	4	Capstone Project - Final	0	0	0	1	0	6
	4	Internship 1	0	0	0	0	1	1*
	4	Comprehensive Examination	1	0	0	0	0	1*
	4	Project Exhibition 1	0	0	0	0	1	1*
	4	Project Exhibition 2	0	0	0	0	1	1*

* Pass/Fail courses

Programme Core/ Major Core (PC/MaC)

Course code	Level	Course title	L	T	P	S	J	C
BTEN1011	1	Biotechnology Workshop	0	0	2	0	0	1
BTEN1031	1	Process Calculations	2	0	0	0	0	2
BTEN2001	2	Biochemistry	2	0	2	0	0	3
BTEN2011	2	Microbiology	2	0	2	0	0	3
BTEN2021	2	Instrumental Methods of Analysis	2	0	0	0	0	2
BTEN2031	2	Genetics & Molecular Biology	3	0	0	0	0	3
BTEN2041	2	Fluid Mechanics & Mechanical Operations	2	0	2	0	0	3
BTEN2051	2	Biochemical Thermodynamics	3	0	0	0	0	3
BTEN3001	3	Biochemical Reaction Engineering	2	0	2	0	0	3
	3	Heat & Mass Transfer	3	0	2	0	0	4
	3	Genetic Engineering	3	0	2	0	0	4
BTEN3031	3	Bioprocess Engineering	3	0	2	0	0	4
BTEN3041	3	Immunotechnology	2	0	2	0	0	3
	3	Bioinformatics	3	0	0	0	0	3
BTEN4001	4	Plant Biotechnology	2	0	2	0	0	3
BTEN4011	4	Process Dynamics and Control	2	0	2	0	0	3
BTEN4021	4	Bioseparation Technology	2	0	2	0	0	3
BTEN4031	4	Animal Biotechnology	2	0	0	0	0	2

Programme Elective (PE)#

Course code	Level	Course title	L	T	P	S	J	C
BTEN3061		Advanced Cell Biology	2	0	2	0	0	3
		Environmental Biotechnology	2	0	2	0	0	3
		Fermentation Technology	2	0	2	0	0	3
BTEN3211		Food Processing Technology	2	0	2	0	0	3
BTEN3091		Sea & Dairy Food Processing	2	0	2	0	0	3
		Biophysics	3	0	0	0	0	3
BTEN3111		Food handling, packaging & Storage	3	0	0	0	0	3
BTEN4041		Food Safety & Quality Management	3	0	0	0	0	3
		Marine Biotechnology	3	0	0	0	0	3
BTEN3131		Pharmaceutical Biotechnology	3	0	0	0	0	3
		Artificial Neural Networks	2	0	2	0	0	3
BTEN4051		Bioprocess Plant design	2	0	2	0	0	3
BTEN3151		Machine Learning in Biotechnology	2	0	2	0	0	3
BTEN3161		Metabolomics & Metabolic Engineering	2	0	2	0	0	3
BTEN4061		Modelling & Simulation in Bioprocesses	2	0	2	0	0	3
		Molecular Diagnostics	2	0	2	0	0	3
BTEN4081		Molecular Modelling & Drug Design	2	0	2	0	0	3
BTEN4091		Systems Biology	3	0	0	0	0	3
BTEN3171		Proteomics & Protein Engineering	2	0	2	0	0	3
BTEN3181		Applied Biocatalysis & Biotransformation	3	0	0	0	0	3
BTEN4101		Genomics & Genome Engineering	3	0	0	0	0	3
BTEN3191		Nanobiotechnology	3	0	0	0	0	3
BTEN3201		Stem Cells & Tissue Engineering	3	0	0	0	0	3
BTEN4111		Synthetic Biology	3	0	0	0	0	3
BTEN4121		Biomedical Engineering	3	0	0	0	0	3
BTEN4131		AI & ML for Bioengineers	3	0	0	0	0	3

Opt any five courses from Programme Elective basket

Open Elective (PE)#

Opt eligible PC/PE courses from other programmes as an open elective courses and earn 24 credits

CSEN1001: IT Productivity Tools

L	T	P	S	J	C
0	**0**	**2**	**0**	**0**	**1***

This course introduces all software tools that improve the productivity of a student in enhancing his learning experience with all the activities taken up as part of his coursework.

Course Objectives

- to enable the learner, the skill in preparing technical documents of professional quality using docs, sheets and forms.
- to involve the student in designing and creating of websites and acquaint the student with the skill of processing audio, images, documents etc.
- to create awareness in analysing data using pivot tables, query manager etc.
- to create awareness in composing emails, mail merge, e-mail merge etc.
- to provide the exposure to work with collaborative tools.

List of Experiments

1. Create a typical document consisting of text, tables, pictures, multiple columns, with different page orientations.
2. Create a technical paper / technical report consisting of table of contents, table of figures, table of tables, bibilography, index, etc.
3. Compose and send customized mail / e-mail using mail-merge.
4. Create / modify a power point presentation with text, multimedia using templates with animation.
5. Create spreadsheet with basic calculations with relative reference, absolute reference and mixed reference methods.
6. Simple report preparation using filtering tool / advanced filtering commands / pivot tables in spreadsheet application.
7. Analyse the results of a examination studentwise, teacherwise, coursewise, institute-wise.
8. Collecting and consolidating data using collaborative tools like google docs, sheets, forms.
9. Create charts / pictures using online tools like: www.draw.io or smartdraw
10. Create a website of his interest.

Text Books:

1. Katherin Murray, 'Microsoft Office 365 Connect and collaborate virtually anywhere, anytime', Microsoft Press, ISBN: 978-0-7356-5694-9
2. EXCEL 2021 The Comprehensive Beginners to Advanced Users Guide to Master Microsoft Excel 2021. Learn the Essential Functions, New Features, Formulas, Tips and Tricks, and Many More
3. https://drawio-app.com/tutorials/video-tutorials/
4. Learning Web Design: A Beginner's Guide to HTML, CSS, JavaScript, and Web Graphics Fourth Edition ISBN-13: 978-1449319274

References/Online Resources

1. https://www.coursera.org/learn/introduction-to-computers-and-office-productivity-software
2. https://www.coursera.org/projects/analyze-data-pivot-tables-crosstabs-google-sheets
3. https://www.coursera.org/learn/excel-advanced#syllabus
4. https://www.coursera.org/learn/how-to-create-a-website
5. https://support.microsoft.com/en-us/office
6. https://www.diagrams.net/
7. https://edu.google.com/

Course Outcomes

- Create / alter documents / Technical Paper / Project report with text, pictures, graphs of different styles.
- Create / modify power point presentations with text, multimedia and to add animation using / creating templates.
- Perform basic calculations / retrieve data / createpivot tables / chart using a spreadsheet application.
- Create simple diagrams / charts using online tools like: www.draw.io .
- Manage documents, presentations, spreadsheets and websites in collaborative mode.

LANG1001: Communication Skills in English - Beginners

L	T	P	S	J	C
0	0	4	0	0	2*

Communication Skills in English (Beginner) is the first of the three-level courses for a developmental enhancement of learners' communication skills in English. This course focuses on giving learners exposure to factual level of comprehension (listening and reading) and application of the learning (Speaking/Writing) with an awareness for social and personality-based variations in communication. In addition to the LSRW skills, the focus of the course is on schematic thinking skills. This course is activity-based and practice-oriented in terms of procedural knowledge of vocabulary and grammatical structure. This syllabus is carefully developed to enable learners to engage in communication in English avoiding errors and be prepared for next level of learning English.

Course Objectives

- Train learners to listen actively, follow what is spoken in standard English, and answer questions to demonstrate their understanding of the main points of the speech, repeat part of what someone has said to confirm mutual understanding, though occasionally, there may be a need to ask for repetition or clarification. (Bloom's Taxonomy Level/s: 2 & 3)

- Equip learners with the skills to read and comprehend straightforward texts and simple argumentative writing to identify the topic, the desired/relevant information, the main points of the argument, and the major conclusion/s. (Bloom's Taxonomy Level/s: 2 & 4)

- Help learners apply their knowledge and language skills to make mini oral presentations, and produce short coherent written texts using appropriate cohesive devices, suitable vocabulary and grammatical structures. (Bloom's Taxonomy Level/s:3)

- Enable learners to communicate with reasonable accuracy in familiar contexts with adequate fluency and generally good control by equipping them with a repertoire of frequently used vocabulary, structures, and speech patterns. (Bloom's Taxonomy Level/s: 2 & 3)

List of Activities & Tasks for Assessment

1. Listening to others and getting to know their experiences, interests and opinions
2. Introducing oneself: Salutation, basic information, relating to the context
3. Starting a conversation: Salutation, expressing purpose, expressing gratitude
4. Sharing one's experiences, interests and opinions
5. Reading short newspaper articles for gist
6. Picking new words from an article and working on them to know the meaning and usage
7. Using the new (unknown) words in own sentences
8. Sharing news with others - initiate, sustain and conclude
9. Understanding the relevance of intonation to meaning from recorded conversations, and applying the learning in pair work (role play)
10. Writing a summary of a story/personal narrative after listening to it twice and making individual notes
11. Reading graphs, charts and maps for specific information, making note of the important information and talking briefly about it within a small peer group
12. Writing a paragraph about oneself: a brief profile including major successes, failures, and goals. Giving compliments/gratitude to others

13. Writing a paragraph (descriptive, complimentary) about others (Family, friends, role model, etc.)
14. Correcting each other’s' drafts: errors in language - word choice, structure, and conventions/etiquette
15. Writing a short structured descriptive/narrative essay in 3 paragraphs, reading others' essays and sharing feedback

References

1. V. Sasikumar, P. Kiranmayi Dutt, Geetha Rajeevan. (2007). Listening and Speaking - Foundation Books Cunninhum, S. & Moor, P. (nd). New Cutting Hedge (Intermediate). Longman
2. Cambrdige Academic English: An Integrated Skills Course for EAP (Intermediate) By Craig Thaine, CUP (2012)
3. Rutherford, Andrea J. (2007). Basic Communication Skills for Technology: Second Edition. Delhi: Pearson Education.
4. McCarthy, M., O'Dell, F., Mark, G. (2005). English Vocabulary in Use. Spain: Cambridge University Press.
5. New Headway Academic Skills: Reading, Writing, and Study Skills Student's Book, Level-1 by Sarah Philpot. OUP
6. Philpot, S. & Curnick, L. (2017). Headway: Academic Skills: Reaing, Writing, and Study Skills. Introductory Level. OUP.
7. Thaine, C. (2012). Cambridge Academic English: An Integrated Skills for EAP . Intermediate. CUP.

Online References

- www.teachingenglish.org.uk
- learnenglishteens.britishcouncil.org
- https://eslflow.com/
- https://www.englishclub.com/
- https://www.oxfordlearnersdictionaries.com/
- https://dictionary.cambridge.org/
- learnenglishteens.britishcouncil.org
- https://freerice.com/categories/english-vocabulary

Course Outcomes

- Listen actively, understand and extract the essential information from short talks/conversations/discussions that are delivered in clear, standard speech. (Bloom's Taxonomy Level/s: 2 & 3)
- Read, understand, and extract specific information from straightforward factual and simple argumentative texts on general topics and subjects of interest. (Bloom's Taxonomy Level/s: 2 & 3)

- Speak clearly with some confidence on matters related to his/her interests and academic work, and make short structured oral presentations on topics of personal interest. (Bloom's Taxonomy Level/s: 3)
- Write short straightforward connected texts on a range of familiar/general topics using appropriate linking devices to achieve a clear sequence of ideas. (Bloom's Taxonomy Level/s: 3)

- Acquire sufficient language competency to express oneself in speech and writing with some confidence, using appropriate vocabulary and simple grammatical structures though lexical limitations and/or difficulty with formulation might be evident at times. (Bloom's Taxonomy Level/s: 2 & 4)

LANG1011: Communication Skills in English

L	T	P	S	J	C
0	0	4	0	0	2

Communication Skills in English (Intermediate) is the second of the three-level graded courses for a developmental enhancement of communication skills in English. Based on the learning outcomes set in the beginner level syllabus, this course focuses on giving learners more exposure to the use of language for communicative purposes and equip them with next level skills (ref. Bloom's taxonomy) and practice in terms of complexity and cognitive engagement. This course also includes inferential level of comprehension (listening and reading) that involves analysis and application of the language skills and decision-making skills while speaking/writing with an awareness for social and personality-based variations in communication. This course emphasizes guided writing through adequate tasks with pre and post context building. The focus is on stimulation and application of critical thinking in addition to schematic thinking for communication in real-life situations.

Course Objectives

- Train learners to actively listen to short audio texts with familiar content; guided activity like question-making and responding to others' questions based on the audio text would help learners engage in transactional dialogue; extended activities like extrapolating/critiquing the responses would help learners enhance their schematic thinking. (Bloom's Taxonomy Level/s: 2 & 4)
- Equip learners with strategies to read actively and critically and understand the writers' viewpoints and attitude by providing reading comprehension tasks using authentic texts such as op-ed articles from newspapers, and reports on contemporary problems. (Bloom's Taxonomy Level/s: 4 & 5)
- Help learners understand various aspects and techniques of effective presentations (group/individual) through demonstration and modelling, and enabling them to develop their presentation skills by providing training in using the tips and strategies given. Learners would be encouraged to observe and express opinion on teacher-modelling. Reflection on issues like anxiety, stage-fear, confidence, and levels of familiarity with topic and audience would be addressed. Practice would be given on tone, pitch, clarity and other speech aspects. Detailed peer feedback and instructor's feedback would cover all the significant aspects. (Bloom's Taxonomy Level/s: 2 & 4)
- Enable learners to become aware of the structure and conventions of academic writing through reading, demonstration, scaffolding activities, and discussion. Corrective individual feedback would be given to the learners on their writing. (Bloom's Taxonomy Level/s: 2 & 3)

List of Tasks and Activities

S. No.	Tasks	Activities
1	Listening to subject related short discussions/ explanations/ speech for comprehension	Pre-reading group discussion, Silent reading (Note-making), Modelling (questioning), Post-reading reflection /Presentation
2	Asking for information: asking questions related to the content, context maintaining modalities	Group role-play in a context (i.e. Identifying the situation and different roles and enacting their roles)

3	Information transfer: Verbal to visual (familiar context), demonstration by teacher, learners' task (guided with scaffolding), learners' task (free), presentation and feedback	Pair work for discussion & feedback, Presentations, question-answer
4	Information transfer: Visual to verbal (unfamiliar context); demonstration by teacher, learners' task (guided with scaffolding), learners' task (free), presentation and feedback	Pre-reading game/modelling, discussion in small groups, individual writing, and feedback
5	Introducing officials to peers and vice versa - Formal context	AV support, noticing, individual performance (3-4), pair work (in context), teacher modelling, group work for Introducing self and others in a formal context
6	Introducing friends to family and vice versa - Informal context	Teacher modelling/AV support, noticing structure & note-taking, Introducing friends and family in an informal context
7	Vocabulary in context: Find clues in a text and use them to guess the meaning of words/phrases. Apply the newly learnt vocabulary in communication (speaking and writing).	Comprehending verbal communication: Identifying the contextual clues in oral and written texts; guessing the meaning of words/phrases in context while reading texts and listening to discussions/talks
8	A five-day journal (diary) writing based on learners reading from newspaper on a single relevant/current social issue. Individual oral presentation and feedback from peers and instructor.	Note-making (group work), Discussion, Feedback
9	Follow the essentials of lectures, talks, discussions, reports and other forms of academic presentations and mak2 individual and group presentations aided with images, audio, video, tabular data, etc.	Making power point presentation aided with images, audio, video, etc. with a small group by listening to academic lectures/talks/ discussions, etc.
10	Self-reflection: Re-reading one's own drafts, identifying errors, correcting the errors, and giving rationalize the changes	Pre-task discussion/modelling, Editing the texts by careful reading and identifying the errors, peer-exchange (Pair work), feedback/consolidation
11	Collaborative work (speaking and writing) in small groups of 3 or 4 learners: discussing a general/discipline-specific topic: creating outline, assigning specific roles to members of the group; and group presentation followed by peer and instructor feedback	Pre-task modelling (peer/teacher), general discussion on structure, group work (collaboration), feedback
12	Independent reading of different text types using appropriate reference sources by adapting suitable reading styles and speed. Focus on active reading for vocabulary: low-frequency collocations and idiomatic expressions.	Brain-storming, mapping of key terms (content specific), reading and note-making (individual), oral questioning, discussion
13	Role-play (specific social and academic situations): planning (making notes), understanding nuances of speaking in context, coordinating with situational clues and fellow speakers/participants	Peer discussion for outline, A-V support, observing (teacher modelling), role play (guided), role-play (free), feedback
14	Writing instructions: Guidelines - Flowcharts - Procedures to be followed	Pre-task reading, pair work, teacher/peer-discussion, feedback
15	Speaking spontaneously on topics of interest and writing short structured essays on the same topics adopting appropriate academic conventions and grammatical accuracy.	Reading for task preparation, note-making, speaking, reflection and corrective peer and teacher feedback

Reference Books

1. P. Kiranmayi Dutt, Geetha Rajeevan. (2007). Basic Communication Skills. Foundation Books. CUP
2. Harmer, J. (1998). How to teach English. Longman
3. Sanjay Kumar & Pushp Lata. (2018). Communication Skills: A Workbook. OUP.
4. Cambridge IGCSE: English as a Second Language Teacher's Book Fourth Edition. By Peter Lucantoni. CUP (2014).
5. Cambrdige Academic English: An Integrated Skills Course for EAP (Upper Intermediate) By Martin Hewings, CUP (2012)
6. Richards, J.C. and Bohlke, D. (2012). Four Corners-3. Cambridge: CUP.
7. Headway Academic Skills: Reading, Writing, and Study Skills Student's Book, Level-2 by Sarah Philpot. OUP
8. Latham-Koenig, C. & Oxenden, C. (2014). American English File. Oxfor: OUP.
9. McCarthy, M. & O' Dell. F. (2016). Academic Vocabulary in Use. Cambridge: CUP

Online Resources

1. https://www.grammarly.com/blog/
2. https://www.nationalgeographic.org/education/
3. https://www.bbc.co.uk/teach/skillswise/english/zjg4scw
4. https://www.englishclub.com/
5. https://www.oxfordlearnersdictionaries.com/
6. https://dictionary.cambridge.org/
7. learnenglishteens.britishcouncil.org
8. https://freerice.com/categories/english-vocabulary
9. http://www.5minuteenglish.com/
10. https://breakingnewsenglish.com/
11. https://www.digitalbook.io/
12. https://librivox.org/

Course Outcomes

- Understand the speaker's point of view in fairly extended talks on general or discipline-specific topics, and follow simple lines of argument in discussions on familiar contemporary issues. (Bloom's Taxonomy Level/s: 3)

- "Read and demonstrate understanding of articles and reports on limited range of contemporary issues in which the writers adopt particular stances. Also provide samples of written communication containing fairly complex information and reasons for choices/opinions/stances. (Bloom's Taxonomy Level/s: 2 & 3)"

- Make short presentations on a limited range of general topics using slides, and engage in small group discussions sharing experiences/views on familiar contemporary issues and give reasons for choices/opinions/plans. (Bloom's Taxonomy Level/s: 3 & 4)

- Write clear, fairly detailed text (a short essay) on a limited range of general topics, and subjects of interest, and communicate clearly through email/letter to seek/pass on information or give reasons for choices/opinions/plans/actions. (Bloom's Taxonomy Level/s: 3)

- Reflect on others' performance, give peer feedback on fellow learners' presentations, responses to writing tasks and reading comprehension questions. (Bloom's Taxonomy Level/s: 5)

LANG1021: Advanced Communication Skills in English

L	T	P	S	J	C
0	0	4	0	0	2

Communication Skills in English (Advanced) is the third of the three-level graded courses for a developmental enhancement of communication skills in English. Based on the learning outcomes set in the upper-intermediate syllabus, this course focuses on giving learners exposure to higher level of skills/input processing (ref. Bloom's taxonomy) and practice in terms of complexity and cognitive engagement. This course includes advanced level of comprehension i.e. anaytical, evaluative and extra-polative processing (listening and reading) and involves problem-solving, logical reasoning and decision-making skills in terms of application of the learning (speaking/writing) with an awareness for social and personality based variations in communication. This course provides opportunities with activity-based practice of advanced oral and written communicative skills besides building awareness on the finer nuances of language use for various purposes. This course emhasizes free writing through meaningfully engaging tasks with a pre and post context building. There is ample scope for application of critical thinking through simulated activities for effective communication in real life situations.

Course Objectives

1. Enable learners to listen actively become aware of tone and attitude in speech, and demonstrate their comprehension of fairly complex lines of argument presented by a variety of speakers in talks/presentations/discussions. (Bloom's Taxonomy Level/s: 2 & 4)

2. Enable learners to become aware of tone and attitude in written texts, and demonstrate their comprehension of fairly complex lines of argument and points of view presented in a variety of texts by equipping them with upper intermediate to advanced level reading skills and strategies. (Bloom's Taxonomy Level/s:2 & 3)

3. Make effective presentations, engage in formal group discussions, and write structured essays/ short reports to highlight the significance of actions/decisions/experiences, and sustain views by providing relevant evidence and argument. (Bloom's Taxonomy Level/s: 3 & 4)

4. Equip learners with the skills and strategies to communicate effectively in speech and writing using the language with a degree of fluency, accuracy and spontaneity, and fairly good grammatical control adopting a level of formality appropriate to the context. Encourage learners to apply their knowledge of language and their communication skills in real life situations. (Bloom's Taxonomy Level/s:3 & 5)

List of Activities & Tasks for Assessment

S.No.	Tasks	Activities	CO
1	Evaluative and extrapolative reading of a long text/short texts on a current topic related to technology and society, identifying and questioning the author's intention, post-reading discussion in small groups, maintaining group dynamics, arriving at a consensus	Pre-reading group discussion, silent reading (Note-making), modelling (questioning), post-reading reflection and brief presentation of thoughts/ideas/opinions on the theme of the text	3
2	Debate in pairs based on listening to two recorded contemporary speeches by well-known leaders in different fields. Peer feedback and instructor feedback.	Pre-recorded audio/video for listening, student checklist for noticing key words/concepts, pre-task orientation (by teacher), pair work, feedback	1
3	Information transfer: Verbal to visual (unfamiliar context); demonstration by teacher, learners' task (guided with scaffolding), learners' task (free), presentation, question-answer(among students), modification and feedback before the final version is done	Pair work for discussion and feedback, presentations, question-answer	2
4	Information transfer: Visual to verbal (unfamiliar context); demonstration by teacher, learners' task (guided with scaffolding), learners' task (free), presentation, question-answer(among students), modification, editing, proofreading, and feedback before the final version is done	Pre-reading game/modelling, discussion in small groups, independent writing and feedback	4
5	Expressing opinion on a short argumentative text (e.g. a journal article or a newspaper editorial) and justifying one's opinion/stance; focus on the use of appropriate conventions of formal and polite speech, and managing bias	Listening to group discussions/debates, reading news-paper articles on the current issues and expressing opinions in favour or against the topic (in GDs, debates or writing argumentative essays).	3
6	Role-play (complex social and academic/professional situations): Focus on significant aspects of delivery including clarity, tone, and use of contextually appropriate vocabulary and conventions, observation, reflective discussion, and self-reflective writing	Reading newspaper/magazine articles/blog posts on current social issues, listening to talks/discussions/debates etc. and participating in role-plays using expressions appropriate to the context.	1
7	Collborative writing in groups of 3 -4 on topics that would require data collection and reading followed by recorded peer-reflection and peer-feedback, group presentation and feedback	Pre-task modelling (peer), general discussion on structure, group work (collaboration), presnetation, peer feedback, Open-class discussion	5
8	Formal Group Discussion on topics of current interest and relevance; focus on effective participation, reflection on control over argument/counter argument, and adherence to the conventions of formal GD	Noticing strategies from AV modelling, teacher scafolding though open-house discussion, Note-making (Group work), Group Discussion (free), post perfromance discussion, Feedback	2

9	Mind-mapping for advanced reading, making correlations across texts, extending author's point of view	Reading texts on abstract topics and comprehending the author's perspective by inferring the unknown words' meaning in the context and making notes using mind-map strategy and presenting it orally.	3
10	Handling question and answer sessions after presentations: justifying arguments, taking counter-arguments, agreeing and disgreeing with rationale	Listening to some lectures, talks, and presentations in the academic seminars and adapting some strategies to handle the Q&A sessions using polite and formal expressions to agree or disagree with the statements.	1
11	Modelling an interview: with a panel of four judges (peers)	Pre-task activity for orientation/strategies (controlled/guided), Model interview (AV support), Group work (role play), interview in pair (one-to-one), Interview in group (many -to-one), oral corrective feedback (peer/teacher)	2
12	Writing a short reflective report of an event - incident/meeting/celebration	Writing a report on meetings/celebrataions/events etc. by actively involving in such events and giving a short oral presentation on the same.	4
13	Speaking on abstract and complex topics beyond his/her own area of interest/field of study, using the language flexibly and effectively.	Reading texts on abstract topics and comprehending the author's perspectives. Similarly, listening to talks and discussions on an abstract topic of other discipline and making short oral presentation by sharing views and opinions.	3
14	Self-relfection on own speech in context(recorded): tone, pitch, relevance, content; extending the reflections/ideas to others	Listening to selected general discussions (audios and videos) and observing the language production. Recording own speech on some general topic and providing a critical review (self-reflection) on it by focusing on the tone, expressions and relevance of the content, etc.	1
15	Collaborative and individual task: planning, preparing (preparing an outline, structure, setting objectives and presenting the plan of action) and executing a mini-project, and submitting a brief report on the same peer and instructor feedback after the planning stage and on completion of the mini project	Pre-task modelling (peer/teacher), general discussion on structure, group work (collaboration), oral corrective, task distribution, presentation, feedback	5

Reference Books

1. Latham-Koenig, C. & Oxenden, C. (2014). American English File-5. Oxford: OUPRichards,
2. J.C. and Bohlke, D. (2012). Four Corners-4. Cambridge: CUP.
3. Cambrdige Academic English: An Integrated Skills Course for EAP (Advanced) By Martin Hewings and Craig Thaine, CUP (2012)

4. Berlin, A. (2016). 50 Conversation Classes: 50 Sets of Conversation Cards With an Accompanying Activity Sheet Containing Vocabulary, Idioms and Grammar. Poland: CreateSpace Independent Publishing Platform
5. Zemach, D. E., Islam, C. (2011). Writing Paragraphs: From Sentence toParagraph. Germany: Macmillan Education.
6. Stewart, J. P., Fulop, D. (2019). Mastering the Art of Oral Presentations: Winning Orals, Speeches, and Stand-Up Presentations. United Kingdom: Wiley.
7. Kroehnert, Gary. (2010). Basic Presentation Skills. Sidney: McGraw Hill.
8. Cunninghum, S. & Moor, P. (nd). Cutting Edge (Advanced) With Phrase Builder. Longman Publishers. CUP
9. McCarthy, M & O'Dell, F. (2017). English Idioms in Use (Advanced). Cambridge: CUP.

Online Resources

1. https://www.grammarly.com/blog/
2. https://www.nationalgeographic.org/education/
3. https://www.bbc.co.uk/teach/skillswise/english/zjg4scw
4. https://www.englishclub.com/
5. https://www.oxfordlearnersdictionaries.com/
6. https://dictionary.cambridge.org/
7. learnenglishteens.britishcouncil.org
8. https://freerice.com/categories/english-vocabulary
9. http://www.5minuteenglish.com/
10. https://breakingnewsenglish.com/
11. https://www.digitalbook.io/
12. https://librivox.org/

Course Outcomes

- Listen to extended lectures, presentations, and discussions on a wide range of contemporary issues and demonstrate understanding of relatively complex lines of argument. (Bloom's Taxonomy Level/s: 2)
- Make presentations using suitable AV aids and engage in formal group discussions on a wide range of topics of contemporary interest, demonstrating awareness of standard/widely accepted conventions. (Bloom's Taxonomy Level/s: 3)
- Read and demonstrate understanding of the writer's stance/viewpoint in articles and reports on a wide range of contemporary issues and discipline-specific subjects. (Bloom's Taxonomy Level/s: 2 & 4)
- Write analytical essays on a wide range of general topics/subjects of interest, and engage in written communication (emails/concise reports) to exchange relatively complex information, giving reasons in support of or against a particular stance/point of view. (Bloom's Taxonomy Level/s: 3 & 4)
- Complete a mini project that necessitates the use of fairly advanced communication skills to accomplish a variety of tasks and submit a report in the given format. (Bloom's Taxonomy Level/s: 4 & 5)

CLAD1001: Emotional Intelligence & Reasoning Skills (Soft Skills 1)

L	T	P	S	J	C
0	0	2	0	0	1

Course Description:

Emotional intelligence is a set of skills that are thought to contribute to the appraisal of emotions in oneself and others. It can also help contribute to the effective regulation of emotions as well as feelings (Salovey & Mayer, 1990). In terms of emotional intelligence, self-awareness and self-management have to do with our ability to relate to ourselves. Social awareness and relationship management have to do with our ability to relate to others. Similarly, the ability to solve questions on Analytical Reasoning and Data Sufficiency is a critical area tested in almost all competitive examinations and admission tests. Upon completion, students should be able (1) to deal with their own emotions as well as the emotions of others and relate better with both. Using better knowledge of EI, students will also be able to set more meaningful goals for themselves, choose suitable time management techniques that work best for them and work in teams more effectively. (2) to apply different concepts, ideas and methods to solve questions in reasoning and data sufficiency

Course Objectives:

1. Use EI to relate more effectively to themselves, their colleagues and to others. Apply self awareness and self assessment (SWOT) to better understand and manage their own emotions. Apply social awareness to empathize with others and build stronger relationships with others.
2. Set meaningful goals based on their strengths and weaknesses and apply time management techniques, such as Q4 organizing to put first things first.
3. Manage conflicts and work in teams in an emotionally intelligent manner.
4. Solve questions on non-verbal and analytical reasoning, data sufficiency and puzzles

Unit	Topics	Hours
1	Self Awareness & Self Regulation: Introduction to Emotional Intelligence, *Self Awareness:* Self Motivation, Accurate Self Assessment (SWOT Analysis), Self Regulation: *Self Control, Trustworthiness & Adaptability*	3
2	Importance, Practising Social Awareness, Building Relationships, Healthy and Unhealthy Relationships, Relationship Management Competencies- Influence, Empathy, Communication, Types of Conflicts, Causes, Conflict Management	3
3	Social Media: Creating a blog, use of messaging applications, creating a website to showcase individual talent, creation of a LinkedIn Profile	2
4	Goal Setting & Time Management: Setting SMART Goals, Time Wasters, Prioritization, Urgent Vs Important, Q2 Organization	3
5	Teamwork: Team Spirit, Difference Between Effective and IneffectiveTeams, Characteristics of High Performance Teams, Team Bonding, Persuasion, Team Culture, Building Trust, Emotional Bank Account	4
6	Verbal Reasoning: Introduction,Coding-decoding, Blood relations, Ranking, Directions, Group Reasoning	6
7	Analytical Reasoning: Cubes and Dices, Counting of Geometrical figures	3
8	Logical Deduction: Venn diagrams, Syllogisms, Data Sufficiency, Binary logic	4
9	Spatial Reasoning: Shapes, Paper Cutting/Folding, Mirror images, Water images and Rotation of figures	2
	Total Hours	30

Course Outcomes

- Students will be able to relate more effectively to themselves, their colleagues and to others
- Students will be able to set their short term and long term goals and better manage their time
- Students will be able to manage conflicts in an emotionally intelligent manner and work in teams effectively
- Students will be able to solve questions based on non-verbal and analytical reasoning, data sufficiency and puzzle

References:

1. Verbal Ability & Reading Comprehension by Arun Sharma and Meenakshi Upadhyay
2. Study material for CAT, SAT, GRE, GMAT by TIME, CareerLauncher and IMS etc.
3. Quantitative Aptitude by R S Agarwal S Chand Publications
4. Quantitative Aptitude by Pearson Publications

CLAD1011: Leadership Skills & Quantitative Aptitude (Soft Skills 2)

L	T	P	S	J	C
0	0	2	0	0	1

Course Description:

Communication Skills is having the ability to convey information to others so that messages are understood and outcomes delivered. Some essential qualities of Communication Skills include understanding the needs of others, clearly communicating messages, adapting the communication style, and using a range of communication methods. Presentation Skills is having the ability to confidently deliver an engaging message to a group of people which achieves the objectives. Some essential qualities of Presentation Skills include a thorough preparation of content, structuring content logically, managing nerves, engaging your audience, delivering presentation objectives, positively influencing the audience, and responding to audience needs. Tackling questions based on numbers, arithmetic, data interpretation and puzzles requires the application of different rules and concepts of numerical computation, numerical estimation, and data estimation.

Course Objectives:

1. Learn and apply, through different individual and group activities, different ideas and skills to communicate in a positive and impressive manner.
2. Apply the goal setting process (based on SWOT) and Q2 organizing for effective time management.
3. Apply different concepts in numbers, numerical computation and numerical estimation to solve questions that often appear in various competitive examinations and admission tests.
4. Apply different concepts for tackling questions based on data interpretation, progression and series that are frequently given in various competitive examinations and admission tests.

Unit	Topics	Hours
1	Communication Skills: *The Communication Process*, Elements of Interpersonal Communication, *Non-Verbal Communication:* Body Language, Posture, Eye Contact, Smile, Tone of Voice, *Barriers to Communication.* Effective Listening Skills: Active Listening, Passive Listening, Asking Questions, Empathizing, Being Non Judgemental, Being Open Minded, Mass Communication: Design of Posters, Advertisements, notices, writing formal and informal invitations	5
2	Focus on Audience Needs, Focus on the Core Message, Use Body Language and Voice, Start Strongly, Organizing Ideas & Using Visual Aids: SPAM Model, Effective Opening and Closing Techniques, Guy Kawasaki's Rule (10-20-30 Rule), Overcoming Stage Fear, Story Telling	3
3	Problem Solving & Decision Making: Difference Between the Two, Steps in Rational Approach to Problem Solving: Defining the Problem, Identifying the Root Causes, Generating Alternative Solutions, Evaluating and Selecting Solutions, Implementing and Following-Up, Case Studies	3

4	Group Discussion: Understanding GD, Evaluation Criteria, Nine Essential Qualities for Success, Positive and Negative Roles, Mind Mapping, Structuring a Response, Methods of Generating Fresh Ideas	4
5	Number Theory: Number System, Divisibility rules, Remainders and LCM & HCF	3
6	Numerical Computation and Estimation - I : Chain Rule, Ratio Proportions, Partnerships & Averages, Percentages, Profit-Loss & Discounts, Mixtures, Problems on Numbers & ages	6
7	Data Interpretation: Interpretation and analysis of data in Tables, Caselets, Line-graphs, Pie-graphs, Box-plots, Scatter-plots and Data Sufficiency	3
8	Mental Ability: Series(Number, Letter and Alphanumeric), Analogy(Number, Letter and Alphanumeric) and Classifications	3
	Total Hours	30

Course Outcomes

- Students will be able to communicate 'one-on-one' and 'one-on-many' confidently using both verbal and non-verbal messages and deliver impressive talks/ presentations to a group both with and without the use of PPTs and create posters, advertisements, etc.
- Students will be able to apply the the rational model of problem solving and decision making in their problem solving and decision making efforts.
- Students will be able to solve questions based on numbers and arithmetic given in various competitive examinations
- Students will be able to solve questions based on data interpretation, progressions and series.

References:

1. Verbal Ability & Reading Comprehension by Arun Sharma and Meenakshi Upadhyay
2. Study material for CAT, SAT, GRE, GMAT by TIME, CareerLauncher and IMS etc.
3. Quantitative Aptitude by R S Agarwal S Chand Publications
4. Quantitative Aptitude by Pearson Publications

CLAD1021: Verbal Ability & Quantitative Ability (Soft Skills 3)

L	T	P	S	J	C
0	0	2	0	0	1

Course Description:

Vocabulary is an important part of verbal ability. An understanding of word formation, prefixes, suffixes and roots is necessary to remember and use a vast repository of words. Approaching words through word families and other ways of groupings is an effective way of gaining mastery over vocabulary. Understanding and getting acquainted with the different rules and exceptions in the use of grammar and structure, especially from the relevant examination point of view, is crucial to cracking questions given in many competitive tests. Similarly, improving reading comprehension skills and test taking abilities in this area takes time and effort, especially given the fact that most students do not possess strong reading habits. In so far as quantitative aptitude is concerned, students need to develop a strong foundation on the basic mathematical concepts of numerical estimation, geometry, mensuration, data sufficiency, etc. to be able to crack different round 1 tests of major recruiters and admission tests of top Indian and foreign universities.

Course Objectives:

1. List and discuss the different word formation methods, word denotation, connotation, collocation, etc. and introduce selected high frequency words, their antonyms, synonyms, etc
2. Apply different advanced reading skills to solve questions based on author's tone, main ideas and sub-ideas, inferences, parajumbles, etc. that are frequently asked in various competitive exams and admission tests.
3. Solve different types of questions based on vocabulary, such as word analogy; structure, grammar and verbal reasoning; introduce common errors and their detection and correction.
4. Solve questions on numerical estimation, mensuration, data sufficiency based on quantitative aptitude. This includes questions on time and work, time and distance, pipes and cisterns, lines and angles, triangles, quadrilaterals, polygons and circles, 2 & 3 dimensional mensuration.

1. **Vocabulary Builder:** Understanding Word Formation, Prefixes, Suffixes and Roots, Etymology, Word Denotation, Connotation and Collocation, Synonyms and Antonyms

2. **Reading Comprehension:** Advanced Reading Comprehension: Types of RC passages, Types of Text Structures, Types of RC Questions: Distinguishing Between Major Ideas and Sub Ideas, Identifying the Tone and Purpose of the Author, Reading Between the Lines and Beyond the Lines, Techniques for Answering Different Types of Questions

3. **Para Jumbles:** Coherence and Cohesion, Idea Organization Styles, Concept of Mandatory Pairs and Its Application: Transitional Words, Antecedent-Pronoun Reference, Article Reference, Cause and Effect, Chronological Order, General to Specify, Specify to General, Idea-Example, Idea-Explanation, Etc.

4. **Grammar Usage:** Rules Governing the Usage of Nouns, Pronouns, Adjectives, Adverbs, Conjunctions, Prepositions and Articles

5. **Numerical Computation and Estimation - II:** Time and Work, Pipes and Cisterns, Time and Distance, Problems on Trains, Boats and Streams, Races and Games of Skill, Simple Interest & Compound Interest

6. **Geometry:** Lines and Angles, Triangles, Quadrilaterals & Polygons, and Circles

7. **Mensuration:** 2-Dimensional Mensuration (Triangles, Quadrilaterals and Circles), 3-Dimensional Mensuration (Cubes, Cuboids, Cylinder, Cone, Sphere)

Course Outcomes:

1. List and discuss word formation methods, selected high frequency words, their antonyms, synonyms, etc.
2. Analyze reading passages and quickly find out the correct responses to questions asked, including para jumbles, by using reading skills like skimming, scanning, reading between the lines, etc.
3. Solve different types of questions based on vocabulary, structure, grammar and verbal reasoning
4. Solve questions on numerical estimation, mensuration, data sufficiency based on quantitative aptitude

References:

1. Verbal Ability & Reading Comprehension by Arun Sharma and Meenakshi Upadhyay
2. Study material for CAT, SAT, GRE, GMAT by TIME, CareerLauncher and IMS etc.
3. Quantitative Aptitude by R S Agarwal S Chand Publications
4. Quantitative Aptitude by Pearson Publications

CLAD1031: Practicing Verbal Ability & Quantitative Aptitude (Soft Skills 4)

L	T	P	S	J	C
0	0	2	0	0	1

Course Description:

A sound knowledge of the rules of English grammar, structure and style and its application in detecting errors in writing are important areas of Verbal Ability frequently tested as a part of the written test in many competitive examinations and admission tests of major recruiters and universities respectively. This module focuses on all important areas of grammar and structure commonly asked in major tests, such as GMAT, CAT, XLRI, CRT, etc. Similarly, in the area of Quantitative Aptitude, different kinds of questions are asked from Combinatorics (Permutations & Combinations, Probability], Cryptarithmetic & Modular Arithmetic (Cryptarithmetic, Application of base system (7, 24), Clocks (Base 24), Calendars (Base 7), and Mental Ability (Number series, Letter series & Alpha numeric series, Analogies (Numbers, letters), Classifications, Algebra (Exponents, Logarithms, Problems related to Equations, Special Equations, and Statistics) . This module focuses on all these areas by building on what the students already learnt in their earlier studies.

Course Objectives:

1. Apply the rules of grammar to solve questions in Error Detection, Sentence Correction and Sentence Improvement.
2. Apply the rules of structure to solve questions in Error Detection, Sentence Correction and Sentence Improvement, Fill-in-blanks and Cloze Passages.
3. Explain methods of solving problems in Combinatorics (Permutations & Combinations, Probability], Cryptarithmetic & Modular Arithmetic (Cryptarithmetic, Application of base system (7, 24), Clocks (Base 24), Calendars (Base 7)]
4. Explain how to solve questions in Mental Ability (Number series, Letter series & Alpha numeric series, Analogies, Numbers, letters, Classifications] and Algebra (Exponents, Logarithms, Problems related to Equations, Special Equations, Statistics)

1. Error Detection: Pronouns, Conjunctions, Prepositions and Articles
2. Error Detection: Tenses and their Uses
3. Sentence Correction: Subject-Verb Agreement, Antecedent-Pronoun Agreement, Conditional Clauses
4. Sentence Correction: Modifiers (Misplaced and Dangling) & Determiners, Parallelism & Word Order, and Degrees of Comparison
5. Combinatorics: Permutations & Combinations, Probability

6. Crypt arithmetic & Modular Arithmetic: Crypt arithmetic, Application of Base System (7, 24), Clocks (Base 24), Calendars (Base 7)

7. Algebra: Exponents, Logarithms, Word-problems related to equations, Special Equations, Progressions, Statistics

Course Outcomes:

1. Identify and correct errors in English grammar and sentence construction
2. Identify and correct errors in Structure, Style and Composition
3. Solve problems in Combinatorics, Cryptarithmetic, and Modular Arithmetic
4. Solve problems in Mental Ability and Algebra

References:

1. Verbal Ability & Reading Comprehension by Arun Sharma and Meenakshi Upadhyay
2. Study material for CAT, SAT, GRE, GMAT by TIME, CareerLauncher and IMS etc.
3. Quantitative Aptitude by R S Agarwal S Chand Publications
4. Quantitative Aptitude by Pearson Publications

VEDC1001: Venture Development

L	T	P	S	J	C
0	0	0	2	0	2

Course Description

In this course, you will discover your deeper self in terms of how you might contribute to society by creating exciting new products and services that can become the basis of a real business. Your efforts, creativity, passion, and dedication to solving challenging problems are the future of our society, both in your country and worldwide.

The course is divided into four sections:

1. Personal discovery of your core values and natural skills
2. Ideation and improving the impact
3. Business model design for the innovation
4. Presenting your idea in a professional manner suitable for a new venture pitch

Each section has key frameworks and templates for you to complete, improving your idea step by step until the final presentation.

First, you will discover your personal values and emerging areas of knowledge that are the foundations of any successful company. Next, you will learn how to develop insight into the problems and desires of different types of target customers and identify the design drivers for a specific innovation. Then, you will learn specific design methods for new products and services. And as important as the product or service itself, it is a strategy for monetizing the innovation – generating revenue, structuring the operating costs, and creating the operating profit needed to support the business, hire new employees, and expand forward.

This project is intended to be for teams of students. Innovation and entrepreneurship are inherently team-based. This course will give you that entrepreneurial experience.

This is the beginning of what might be the most important journey of personal and career discovery so far in your life, one with lasting impact. This is not just a course but potentially an important milestone in your life that you remember warmly in the years to come.

Course Objectives

Students will have the opportunity to:

- Discovery who you are – Values, Skills, and Contribution to Society
- Understand how creativity works and permeates the innovation process
- Learn the basic processes and frameworks for successful innovation.
- Gain experience in actually going through the innovation process.
- Conduct field research to test or validate innovation concepts with target customers.
- Understand innovation outcomes: issues around business models, financing for start-ups, intellectual property, technology licensing, corporate ventures, and product line or service extensions.

Course Materials

- Meyer and Lee (2020), Personal Discovery through Entrepreneurship, The Institute for Enterprise Growth, LLC. Boston, MA., USA
- Additional readings

- Additional videos, including case studies and customer interviewing methods.

Expectations of you in the classroom: Each student is expected to be prepared to discuss the readings/exercises assigned for each class. It's not optional! Students will be randomly asked to discuss and summarize the material. Your learning – and your success—in this course are heavilydependent upon your willingness to participate actively in class discussion. Your class participation will be assessed on the quality and consistency of your effort in each and every class.

Late assignments: Late assignments are subject to grade penalty. Lateness will only be considered for grading if prior notice was given to the instructor before the due date.

Presentation: Achieving success with an innovative idea requires you to package and present the idea in a crisp, creative, and powerful manner. The activity of presenting helps you to internalize your idea -- as you talk about it and obtain feedback – and improve upon it. There would be two major presentations during the course, plus a series of other smaller unscheduled presentations of work in progress or course material. Prepare, practice, and succeed!

Time spent outside of class: The course is hands-on and requires students to conduct field research through direct interactions with people (interviews/surveys) and online/in the library. Specifically, the course requires that students conduct studies with potential target users and stakeholders. You must be prepared to go out of your comfort zone to dig for information. You will need to search for information online and arrange to meet or talk to relevant people who may have the information you need.

Group Project Overview

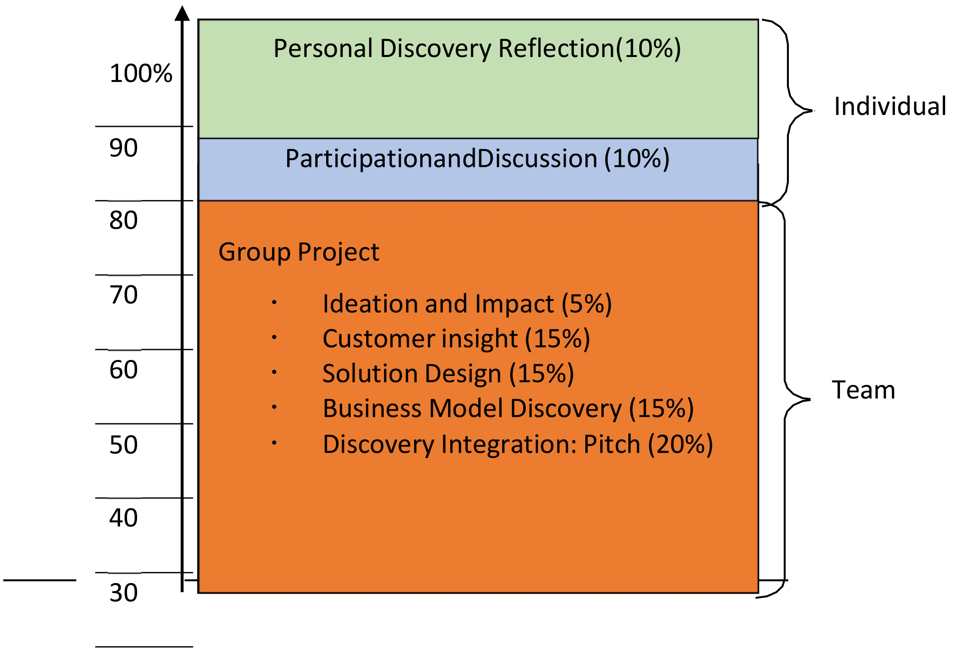
This is a semester length project and the cornerstone component of the course. The group project will give you the opportunity to apply the course concepts to a real situation. You will learn about the entrepreneurship for your own business or your work in organizations. Even if you are not going to be an entrepreneur, you need to know how to identify the opportunities, who to persuade people, and how to create economic and social values in many different contexts.

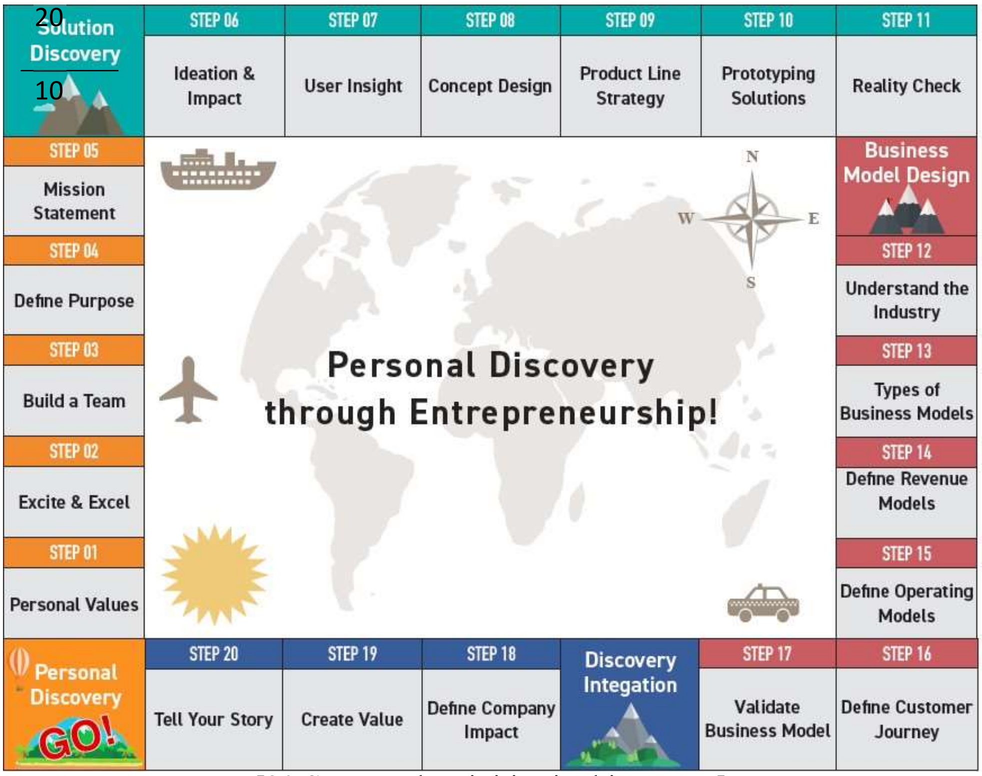
Talking to customers is one of the most important steps in investigating your business because your entrepreneurial vision must correspond to a true market opportunity. With your group, select 5-6 potential customers willing to be interviewed. They should represent a cross-section of our target market and should provide information that helps you refine your opportunity. This is not a simple survey: you are seeking in-depth understanding of the lifestyle and behaviors of your customer that can help you shape your opportunity. Please remember, you are not simply looking to confirm you have a great idea, but to shape your idea into a great opportunity. You will maximize your chances for success and your ability to execute your business cost-effectively by making early (rather than later) changes to your concept.
"Design" is fun, particularly when you merge customer insight with your own creativity. Enjoy! In this book, we provide structured methods to be an active listener and learner from customers as well as a product or service designer.

Business modeling is not as hard as it might sound. This is the design of your business – how it charges customers, what is spent producing and selling products or services, and the money that can be made for each unit sold. We keep it simple – so should you.

For the final outcome, you will be required to come up with Pitch that can used as the basis for actually starting a company based on an impactful innovation. Once again, we provide a specific format and tools for creating a compelling Pitch. We also want you to think about an exciting proposition that is more than just making money, but rather, one that helps society. This will give you innovation and venture concept greater lift with customers – and it will also make you feel better, deep inside.

Project Components and Grading





[20 Steps and activities in this course]

Deliverables

There are a number or different deliverables for the course that follow the templates presented in the book, as applied to your own venture idea. Do your best to keep up with the timeline of the class; do not fall behind! Later templates build on the learnings from prior templates. Make the most of your team! Everyone needs to pitch in. In no case, should one person be taking the lead on all templates.Rather,different team members should take the lead on specific deliverables. Coordinate well. Let your teacher know if a team member is not carrying his or her load.

Specific Deliverables

Ideation and Impact Hand-in Package: 5% of total grade
clearly written, with a one-page explanation for the team's decision

- Problem to Solve Templates, Step 4, Page 62 and 63
  (with a page of additional explanation if needed)
- Idea Impact Template, Step 6, Page 69 (with a page of explanation)

Customer Interviews and Insight Hand-in Package: 15%
(1st Round of Customer Interviews)

- Customer Interviews Template, Step 7, Pages 75-78,plus add additional template forms for each additional customer interview. The more, the better.
- Idea Reshaping Template, Step 7, Pages 84 and 85. Integration into overall conclusions. How have you improved your original idea through customer research?
- Latent Needs Template, Step 7, Page 93 – what are the frustrations of users that are not solved by current products or services?
- Full Use Case Template, Step 7, Page 99 – how do you customers' needs change over the full use case, and what innovative ideas can you propose at each step of the way?

Concept Design (and Test) Hand-in Package: 15%

- Customer Value Proposition Template: Step 8, Page 107. This becomes the landing point for what you learned in your customer interviews.
- Competitive Analysis Template: Step 8, Page 109. (Use the Web or actual stores/dealers)
- Product Vision and Subsystem Design Templates:Step 10, Pages 121 and 126 (You can add additional pages with design illustration and explanations of your bubble chart)
- Reality Check Survey Template and Results: Step 11, Page 141, 143-144
  (You can use more than 2 pages for reporting the results.)

Business Model Design Hand-in Package: 15%

- Industry Analysis Templates: Step 12, Pages 153 and 154
- Illustrate the Business Model Template: Step 13, Page 170
  (Use different colours or line patterns to show the flows of product, money, and information)
- Revenue Model Template: Step 14, Page 177
- Operating Model Template: Step 15, Page 187
- Customer Journey Template: Step 16, Page 195
- Validating the Business Model Template: Step 17, Pages 199 and 200

Discovery Integration Hand-in Package: 20%

- Business and Social Vision Impact Statement Template: Step 18, Page 210.
- Per Unit Profitability Template: Step 19, Page 229
- Your Venture Story Pitch: Step 20(PowerPoint)
- Overall Pitch Design Template:Page 264

Assemble the templates from all your work above, plus any others that you found particularly meaningful, and from these, create your Team's Innovation Pitch.The book has lists specific templates that fit for each part of the final presentation.

Do not just regurgitate the templates in your pitch; rather, take the key points from them to create your own, unique presentation. The templates help you think – but most are toocomplex to present to outside people who have not taken the course. Therefore, design thispitch as if you presenting to a new set of investors.

And don't forget to add an attractive title page with your team members names and email addresses!You can also add an Appendix at the very back with particularly interesting information, such as industry data or the results of your customer interviews and Reality Check.

Individual Innovation Assignments

You will be required to submit two Reflection Journalsas well as a maximum two pages double spaced Synthesis, Integration and Application paper by email at the Week 4 and Week 14 respectively. Please note, this exercise is not about regurgitating the course concepts.

(1) Personal Discovery Reflection Journal (10%)

At the beginning of this semester, you will have a time to think about your self (who you are, what you are good at, what areas you want to contribute on) using a couple of templates. After that sessions, you will have a quiet moment to think about yourself, yourcareer, and your happiness in your life. Please write 2-page reflectional journal what you feel and learning through the personal discovery sessions.

(2) Insight Learning Reflection Journal (10%)

At the end of this semester, you are to prepare a short reflection of impressive sessions aswell as related activities outside the classroom. Specially, (1) reflect on the key points from lectures, reading, discussion, guest speakers, and interviews, (2) apply this to your own situation, and (3) outline ways that you intend to use this knowledge in the future.

<u>Course Schedule</u>

<table>
<tr><th>Week</th><th>Session</th><th>Topics and Steps</th><th>Key CONCEPTS Introduced in Class</th><th>Class Focus Activity</th></tr>
<tr><td rowspan="2">1</td><td>1</td><td>Course Overview</td><td>1. Why is entrepreneurship important?
2. What is Personal Discovery through Entrepreneurship?
3. Four Stages; Personal Discovery, Solution Discovery, Business Model Discovery, Discovery Integration
4. Preparation (finding interesting areas)</td><td>Lecture and Discussion</td></tr>
<tr><td>2</td><td>Personal Discovery
(Step 01, Step 02)</td><td>1. Personal Values
2. Strength and Weakness</td><td>Individual:
· Work with the templates provided on pages:
· Core values: 22, 23
· Skills: 27, 28, 29, 30, 31
· Societal Contribution: 33, 34</td></tr>
<tr><td rowspan="2">2</td><td>3</td><td>Find Teammates
(Step 03)</td><td>1. Review Problem Area Template at the beginning of the book to find classmates who want to work on the same problem area.

2. Findteammates
(1) Shared values
(2) Levels of commitment
(3) Skills and experiences (Same or Different?)</td><td>Problem template: Page 9
· Talk to your classmates and find teammates. See who wants to work on in the same problem space, with a shared vision of solutions, and complementary skill sets.
· Sit back and assess: Team templates on Pages 44, 45, and 46.
· Prepare to present your team, the problem it is going to tackle, and its collective skills.</td></tr>
<tr><td>4</td><td>Define Purpose
(Step 04)
Create Mission
(Step 05)</td><td>1. Methods for defining and refining a venture’s purpose
2. Defining a Venture’s Purpose
3. Creating a Vision Statement</td><td>Team:
· Purpose and Mission Templates: Pages 49 and 52
· Be prepare to present to the class.
· Personal Discovery Reflection Journal Due</td></tr>
</table>

<table>
<tr><th>We ek</th><th>Sess ion</th><th>Topics and Steps</th><th>Key CONCEPTS Introduced in Class</th><th>Class Focus Activity</th></tr>
<tr><td rowspan="2">3</td><td>5</td><td rowspan="2">Ideation & Impact
(Step 06)</td><td>Ideation Methods
・ An in-class ideation exercise</td><td>Team:
・ Problem to Solve Templates, Step 4, Page 62, and 63</td></tr>
<tr><td>6</td><td>Increasing the Impact of an Idea. (The Eat-Your-Coffee Video – a good example of ideation)</td><td>Team:
・ Idea Impact Template, Step 6, Page 69</td></tr>
<tr><td rowspan="2">4</td><td>7</td><td rowspan="2">User Insights Frameworks
(Step 07)</td><td>・ Identifyand find the right target users.
・ Interview style and methods
・ The Customer Interview template.</td><td>Team:
・ Customer Interviews Template, Step 7, Pages 75
・ Edit interview template for your project.</td></tr>
<tr><td>8</td><td>Laddering methods for interviews</td><td>Team:
・ Latent Needs Template, Step 7, Page 93</td></tr>
<tr><td rowspan="2">5</td><td>9</td><td rowspan="2">User Insights Customer Interviews
(Step 07)</td><td>・ Finding latent needs
・ Field work check-in</td><td>Team:
・ Latent Needs Template, Step 7, Page 93
・ Field work – customer interviewing</td></tr>
<tr><td>10</td><td>・ Think about innovation across the entire use case
・ Field work check-in</td><td>Team:
・ Full Use Case Template, Step 7, Page 99
・ Field work – customer interviewing</td></tr>
<tr><td rowspan="2">6</td><td>11</td><td rowspan="2">User Insights Interpreting Results
(Step 07)</td><td>・ Interpreting customer interview results
・ Field work check-in</td><td>Team:
・ Field work – customer interviewing
・ Also talk to retailers/dealers if appropriate</td></tr>
<tr><td>12</td><td>・ Idea Reshaping based on Customer Interviews
・ Field work check-in</td><td>Teams prepare results of results from customer interviews and how the original ideas have been reshaped& improved.</td></tr>
<tr><td rowspan="2">7</td><td>13</td><td rowspan="2">User Insights Interpreting Results
(Step 07)</td><td rowspan="2">・ Customer Research Reports
・ Implications for product and service design</td><td rowspan="2">・ Teams prepare PPTs for class presentation
・ Customer Insight Template Hand-in Package</td></tr>
<tr><td>14</td></tr>
</table>

Week	Session	Topics and Steps	Key CONCEPTS Introduced in Class	Class Focus Activity
8	15	**Concept Design** (Step 08)	· Defining Customer Value · Understanding Customer Value Proposition	Team: · Customer Value Proposition · Template: Step 8, Page 107 · Draft the CVP
	16		· Presentation and review of CVPs	Team: · Complete CVP
9	17	**Competitive Analysis and Positioning** (Step 08)	· Understanding of Competitive Matrix · Competitive positioning: creating your separate space	Team: · Identify major competitors, and dimensions for analysis · Template: Step 8, Page 109
	18		· Presentations of Competitive Analyses and Positionings	Team: · Perform the competitive analysis and present results, including positioning
10	19	**Product Line Strategy** (Step 09)	· Product line framework: good, better, best on underlying platforms, plus application to Services.	Team: · Identify good, better, best variations based on the underlying concept. · Product line template: Page 115
	20	**Product Visioning Subsystem Design, and Prototype Sketch** (Step 10)	· The structured bubble chart, showing implementation options and the team's choices · Prototype sketching (The Bluereo Video is a good example of iterative prototyping driven by customer discovery.)	Team: · Prototype sketch, and for Web apps, a wireframe. For physical products, an initial bill of materials. · Underlying bubble chart showing your decision process. · Product Vision and Subsystem Design Templates: Step 10, Pages 121 and 126
Week	**Session**	**Topics and Steps**	**· Key CONCEPTS Introduced in Class**	**Team or Individual Activity**
11	21	**Reality Check** (Step 11)	· The purpose of the Reality Check, testing the product concept, channel preferences, and much other.	Team: · Reality Check Survey Template and Results: Step 11, Page 141, 143-144

	22		· Guidance on the number or additional customers for the reality check survey · How to analyze and interpret the results	· Customize the Reality Check template for your venture. · Do a quick round of customer surveying. Aim for 12 more interviews.
12	23	**Industry Analysis** (Step 12)	· Team reports on Reality Check Results · Examine major components of an Industry Analysis · Review Templates	Team: · Prepare and present the results of your reality check, plus any pivots you wish to make. · **Concept Design (and Test) Hand-in Package** · Industry Analysis Templates: Step 12, Pages 153 and 154s
	24	**Business Model** (Step 13)	· Defining the Business Model: · Lecture on basic structure and different types. · Illustrating it as the flow of product, money, and information.	Team: · Business Model Illustration Template, Step 13, Page 170

Week	Session	Topics and Steps	· Key CONCEPTS Introduced in Class	Team or Individual Activity
13	25	**Business Model** (Steps 14, 15, 16, 17)	· Revenue and Expenses · The key decision points in the Revenue Model · The key decision points in the Operating Model · Designing the Customer Journey · Validating the Business Model (The Polka Dog Bakery Video: an example of creating a new retail experience, plus new products.)	Team · Step 14, Page 177 · Step 15, Page 187 · Step 16, Page 195 · Step 17, Pages 199 and 200 · Validate the Revenue and Operating Model by trying to have phone calls with a few Sellers and Manufacturers to validating pricing, channels, and costs.
	26			
14	27	**Impact Visioning** (Step 18)	· Develop clear statements for business and societal impact. · Look at good existing examples of companies that do both.	Team: · Start integrating your research and templates towards the final presentation, provided in Step 20, Page 264 · **Business Model Design Hand-in Package**
	28	**Creating Value** (Step 19)	· Develop a project of the profitability in make low volumes for a product, a service, and a Web app. · Discuss applications of the framework to your venture.	Team: · Develop and present Unit of 1 Economics Template, Step 19, Page 229 · Keep working on the Final presentation

Week	Session	Topics and Steps	Key CONCEPTS Introduced in Class	Team or Individual Activity
15	29 30	**Tell Your Story**	• Presentation Format and Style • Format: (1) Title Slide with names and contact information (2) The Target Customer and the Problem to be Solved (3) The Market Opportunity (4) The Innovation Story (5) The Business Model Story (6) The Customer Journey (7) The Team (8) The Proposed Action Steps. (9) Appendices (if needed or desired) • If you have built a prototype during the class, please bring it and show it to us! (The Fortify Video is a good example of how a good technical idea can translate into a business model, and next, into a well-funded venture.)	Team: • The PPT Presentation  • Practice, practice, practice! • Not too many words on one slide • Use pictures • Use template to develop your thinking, but try to create slides that are not just the templates.
Final Course Deliverables			Due on the Monday after the weekend of the final class meeting.	**Team: Your Venture PPTs** **Individual: Insight Learning Reflection Journal**

Course Outcomes

5. Identify one's values, passions, skills and their will to contribute to society
6. Formulate an idea and validate it with customers
7. Demonstrate prototyping and analyze the competition for the product
8. Create business models for revenue generation and sustainability of their business
9. Come up with a pitch that can used as the basis for actually starting a company based on an impactful innovation and societal impact

DOSP1001: Badminton

L	T	P	S	J	C
0	0	0	2	0	2*

This course provides instruction and the opportunity for participation in sports and physical fitness activities. Skills, strategies, rules, and personal wellness goals are included as appropriate. This course will provide students with an understanding of the fundamental concepts of the physiological functions and training principles associated with the chosen sport.

Course Objectives:

1. Understand training principles used in the sport
2. Demonstrate knowledge of the game in a recreational /competitive play setting
3. Organize an event around the sport
4. Demonstrate concepts of warm up, game conditioning, training plans

Course Outcomes:

1. Learn to play Badminton
2. Understanding of the fundamental concepts such as rules of play, game variations
3. Understanding of the governing structure and administration of the sport
4. Understand the event management of the sport
5. Apply sport concepts into an active physical lifestyle

List of Activities:

1. Watch a sport documentary / training video / game history
2. On field coaching and demonstration session
3. Guided practice and play
4. Event management & game officiating
5. Friendly competitions and structured matches

Instructional Plan:

1. Introduction to Badminton - History and development
2. Rules of the Game, Play Area & dimensions
3. Fundamental Skills - Badminton: Grips - Racket, shuttle
4. Sports Specific fitness and warmup drills
5. Stances and footwork
6. Badminton Gameplay: Service, Forehand, Backhand
7. Preparatory Drills and Fun Games
8. Game Variations: Singles/ Doubles/ Mixed

Reference:

1. Handbook of the Badminton World Federation (BWF)

DOSP1011: Chess

L	T	P	S	J	C
0	0	0	2	0	2*

This course provides instruction and the opportunity for participation in sports and physical fitness activities. Skills, strategies, rules, and personal wellness goals are included as appropriate. This course will provide students with an understanding of the fundamental concepts of the physiological functions and training principles associated with the chosen sport.

Course Objectives:

1. Understand training principles used in the sport
2. Demonstrate knowledge of the game in a recreational /competitive play setting
3. Organize an event around the sport
4. Demonstrate concepts of warm up, game conditioning, training plans

Course Outcomes:

1. Learn to play Chess
2. Understanding of the fundamental concepts such as rules of play, game variations
3. Understanding of the governing structure and administration of the sport
4. Understand the event management of the sport
5. Apply sport concepts into an active physical lifestyle

List of Activities:

1. Watch a sport documentary / training video / game history
2. On field coaching and demonstration session
3. Guided practice and play
4. Event management & game officiating
5. Friendly competitions and structured matches

Instructional Plan:

1. Introduction to Chess - History and development
2. Rules of the Game, Play Area & dimensions
3. Fundamental Skills - Chess: Pieces & functions, basic play
4. Chess board moves & terminology
5. Chess Gameplay: Openings, castling, strategies & tactics
6. Preparatory Drills and Fun Games
7. Game Variations & Officiating

Reference:

1. International Chess Federation (FIDE) Handbook

DOSP1031: Football

L	T	P	S	J	C
0	0	0	2	0	2*

This course provides instruction and the opportunity for participation in sports and physical fitness activities. Skills, strategies, rules, and personal wellness goals are included as appropriate. This course will provide students with an understanding of the fundamental concepts of the physiological functions and training principles associated with the chosen sport.

Course Objectives:

1. Understand training principles used in the sport
2. Demonstrate knowledge of the game in a recreational /competitive play setting
3. Organize an event around the sport
4. Demonstrate concepts of warm up, game conditioning, training plans

Course Outcomes:

1. Learn to play Football
2. Understanding of the fundamental concepts such as rules of play, game variations
3. Understanding of the governing structure and administration of the sport
4. Understand the event management of the sport
5. Apply sport concepts into an active physical lifestyle

List of Activities:

1. Watch a sport documentary / training video / game history
2. On field coaching and demonstration session
3. Guided practice and play
4. Event management & game officiating
5. Friendly competitions and structured matches

Instructional Plan:

1. Introduction to Football - History and development
2. Rules of the Game, Play Area & dimensions
3. Fundamental Skills - Kicking, heading, ball control, Keeping
4. Movement, throwins, tackling, defense, scoring, defense
5. Gameplay- Formations, passing, FKs, CKs, PK, tactics
6. Preparatory Drills and Fun Games
7. Game Variations: Small sided games, 7v7, 11v11

Reference:

1. FIFA Laws of the Game

DOSP1041: Volleyball

L	T	P	S	J	C
0	0	0	2	0	2*

This course provides instruction and the opportunity for participation in sports and physical fitness activities. Skills, strategies, rules, and personal wellness goals are included as appropriate. This course will provide students with an understanding of the fundamental concepts of the physiological functions and training principles associated with the chosen sport.

Course Objectives:

1. Understand training principles used in the sport
2. Demonstrate knowledge of the game in a recreational /competitive play setting
3. Organize an event around the sport
4. Demonstrate concepts of warm up, game conditioning, training plans

Course Outcomes:

1. Learn to play Volleyball
2. Understanding of the fundamental concepts such as rules of play, game variations
3. Understanding of the governing structure and administration of the sport
4. Understand the event management of the sport
5. Apply sport concepts into an active physical lifestyle

List of Activities:

1. Watch a sport documentary / training video / game history
2. On field coaching and demonstration session
3. Guided practice and play
4. Event management & game officiating
5. Friendly competitions and structured matches

Instructional Plan:

1. Introduction to Volley - History and development
2. Rules of the Game, Play Area & dimensions
3. Fundamental Skills - Striking, Ball control, Lifting
4. Sports Specific fitness and warmup drills
5. Stances and footwork
6. Preparatory Drills and Fun Games
7. Gameplay: Jumps, strikes, layoffs, attack, defense

Reference:

1. FIVB - Official Volleyball Rules

DOSP1051: Kabaddi

L	T	P	S	J	C
0	0	0	2	0	2*

This course provides instruction and the opportunity for participation in sports and physical fitness activities. Skills, strategies, rules, and personal wellness goals are included as appropriate. This course will provide students with an understanding of the fundamental concepts of the physiological functions and training principles associated with the chosen sport.

Course Objectives:

1. Understand training principles used in the sport
2. Demonstrate knowledge of the game in a recreational /competitive play setting
3. Organize an event around the sport
4. Demonstrate concepts of warm up, game conditioning, training plans

Course Outcomes:

1. Learn to play Kabaddi
2. Understanding of the fundamental concepts such as rules of play, game variations
3. Understanding of the governing structure and administration of the sport
4. Understand the event management of the sport
5. Apply sport concepts into an active physical lifestyle

List of Activities:

1. Watch a sport documentary / training video / game history
2. On field coaching and demonstration session
3. Guided practice and play
4. Event management & game officiating
5. Friendly competitions and structured matches

Instructional Plan:

1. Introduction to Kabaddi - History and development
2. Rules of the Game, Play Area & dimensions
3. Fundamental Skills - Raiding, catching
4. Sports Specific fitness and warmup drills
5. Stances and footwork
6. Preparatory Drills and Fun Games
7. Gameplay: Chain system movement

Reference:

1. Amateur Kabaddi Federation of India (AKFI) - Official Rules
2. Rules of Kabadddi - International Kabaddi Federation

DOSP1091: Basketball

L	T	P	S	J	C
0	0	0	2	0	2*

This course provides instruction and the opportunity for participation in sports and physical fitness activities. Skills, strategies, rules, and personal wellness goals are included as appropriate. This course will provide students with an understanding of the fundamental concepts of the physiological functions and training principles associated with the chosen sport.

Course Objectives:

1. Understand training principles used in the sport
2. Demonstrate knowledge of the game in a recreational /competitive play setting
3. Organize an event around the sport
4. Demonstrate concepts of warm up, game conditioning, training plans

Course Outcomes:

1. Learn to play Basketball
2. Understanding of the fundamental concepts such as rules of play, game variations
3. Understanding of the governing structure and administration of the sport
4. Understand the event management of the sport
5. Apply sport concepts into an active physical lifestyle

List of Activities:

1. Watch a sport documentary / training video / game history
2. On field coaching and demonstration session
3. Guided practice and play
4. Event management & game officiating
5. Friendly competitions and structured matches

Instructional Plan:

1. Introduction to Basketball - History and development
2. Rules of the Game, Play Area & dimensions
3. Fundamental Skills - Passing, Receiving, Dribbling
4. Sports Specific fitness and warmup drills
5. Stances and footwork: Jumps, dribbles, catching, throws
6. Preparatory Drills and Fun Games
7. Gameplay: Shots, throws, movements, attack, defense

Reference:

1. FIBA Basketball Official Rules

DOSP1111: Throwball

L	T	P	S	J	C
0	0	0	2	0	2*

This course provides instruction and the opportunity for participation in sports and physical fitness activities. Skills, strategies, rules, and personal wellness goals are included as appropriate. This course will provide students with an understanding of the fundamental concepts of the physiological functions and training principles associated with the chosen sport.

Course Objectives:

1. Understand training principles used in the sport
2. Demonstrate knowledge of the game in a recreational /competitive play setting
3. Organize an event around the sport
4. Demonstrate concepts of warm up, game conditioning, training plans

Course Outcomes:

1. Learn to play Throwball
2. Understanding of the fundamental concepts such as rules of play, game variations
3. Understanding of the governing structure and administration of the sport
4. Understand the event management of the sport
5. Apply sport concepts into an active physical lifestyle

List of Activities:

1. Watch a sport documentary / training video / game history
2. On field coaching and demonstration session
3. Guided practice and play
4. Event management & game officiating
5. Friendly competitions and structured matches

Instructional Plan:

1. Introduction to Throwball - History and development
2. Rules of the Game, Play Area & dimensions
3. Fundamental Skills - Throwing, Receiving
4. Sports Specific fitness and warmup drills
5. Stances and footwork
6. Preparatory Drills and Fun Games
7. Gameplay: Shots, throws, movements, control

Reference:

1. World Throwball Federation - Rules of the Game

DOSL1001: Club Activity – Participant

L	T	P	S	J	C
0	0	0	2	0	2*

This course recognizes student participation in multiple activities organized by various student organizations that pursue specific co-curricular and extra-curricular interests. These activities allow students to engage in and identify and pursue their personal interests and hobbies.

Course Objectives

- Create opportunities for students to participate in a variety of non-academic experiences
- Interact with and learn from peers in a setting without an external performance pressure
- Allow exploration of interesting activities and reflection about these experiences
- Learn to manage time effectively

List of Student Club Activities

1. Music (vocals, instruments, technical, recording, mixing, production, management)
2. Dance (Indian classical, western, jazz, latin, contemporary, folk, production, event management)
3. Theatre (classical, experimental, one-act, street, production, direction, casting, etc.)
4. Arts (fine arts, painting, calligraphy, sketching, caricaturing, etc)
5. Craft (origami, model making, sculpture, pottery, etc)
6. Cooking (home-style, baking, confectionery, Indian, intercontinental, etc.)
7. Graffiti (street, mural, collage, multi media, etc)
8. Workshops, quizzes, debates, elocution, etc
9. Filmmaking (adventure, drama, film appreciation, documentary, etc)
10. Photography (conventional, immersive (360), landscape, portrait, technical, editing, etc.)
11. College Fests
12. Designing (graphic design, landscape, interior, etc)
13. Competitive coding
14. Recreational sports activities
15. Other club activities organized by student clubs

List of Activities

1. Participation in various club based activities
2. Weekly reflection paper
3. Portfolio (on social media using an instagram account)
4. Two learning papers (one per semester)

Text Books

1. Small move: big Change (Caroline Arnold)
2. How to Win at College: Surprising Secrets for Success from the Country's Top Students (Cal Newport)

References

1. Making the most of college: Students speak their minds (author - Richard Light)
2. Failing Forward: Turning Mistakes into Stepping Stones for Success (John C Maxwell)
3. The Last Lecture (Randy Pausch)
4. Lean in (Sheryl Sandberg)
5. Youtube- Introduction to various club activities

Course Outcomes

Upon successful completion of the course, student will be able to

- Identify personal interest areas
- Learn from diverse perspectives and experiences
- Gain exposure to various activities and opportunities for extra-curicular activities
- Learn to manage time effectively
- gain confidence

DOSL1011: Club Activity – Member of the Club

L	T	P	S	J	C
0	0	0	2	0	2*

This course encourages and acknowledges student members' work in organizing events and activities organized by various student organizations that pursue specific co-curricular and extra-curricular interests. These activities allow students to actively learn from the process of conceptualizing and organizing such activities as part of a team.

Course Objectives
- Create opportunities for students to learn from organizing club activities
- Learn teamwork, leadership, planning and management of events and activities
- Learn to appreciate multiple perspectives, cultures, and individual capabilities
- Learn to manage time effectively

List of Student Club Activities
1. Music (vocals, instruments, technical, recording, mixing, production, management)
2. Dance (Indian classical, western, jazz, latin, contemporary, folk, production, event management)
3. Theatre (classical, experimental, one-act, street, production, direction, casting, etc.)
4. Arts (fine arts, painting, calligraphy, sketching, caricaturing, etc)
5. Craft (origami, model making, sculpture, pottery, etc)
6. Cooking (home-style, baking, confectionery, Indian, intercontinental, etc.)
7. Graffiti (street, mural, collage, multi media, etc)
8. Workshops, quizzes, debates, elocution, etc
9. Filmmaking (adventure, drama, film appreciation, documentary, etc)
10. Photography (conventional, immersive (360), landscape, portrait, technical, editing, etc.)
11. College Fests
12. Designing (graphic design, landscape, interior, etc)
13. Competitive coding
14. Recreational sports activities
15. Other club activities organized by student clubs

List of Activities
1. Be a member of a club and organize activities in that particular interest area
2. Learn from diverse perspectives and experiences
3. Learn to design and execute extra-curicular activities
4. Develop management skills through hands on experience
5. Explore different managerial roles and develop competencies

Text Books
1. Small move: big Change (Caroline Arnold)
2. How to Win at College: Surprising Secrets for Success from the Country's Top Students (Cal Newport)

References

1. Making the most of college: Students speak their minds (author - Richard Light)
2. Failing Forward: Turning Mistakes into Stepping Stones for Success (John C Maxwell)
3. The Last Lecture (Randy Pausch)
4. Lean in (Sheryl Sandberg)
5. Youtube- Introduction to various club activities

Course Outcomes

Upon successful completion of the course, student will be able to

- Be a member of a club and organize activities in that particular interest area
- Learn from diverse perspectives and experiences
- Learn to design and execute extra-curicular activities
- Develop management skills through hands on experience
- Explore different managerial roles and develop competencies

DOSL1021: Club Activity – Leader of the Club

L	T	P	S	J	C
0	0	0	2	0	2*

This course encourages and recognizes student members' work in leading the student organizations through various leadership roles. As leaders they work not just to organize events and activities in specific co-curricular and extra-curricular interests, but also lead the teams that form the core members of the clubs. These activities allow students to learn and practice leadership and management skills through real world experience.

Course Objectives

- Create opportunities for students to learn from organizing club activities
- Learn teamwork, leadership, planning and management of events and activities
- Learn to appreciate multiple perspectives, cultures, and individual capabilities
- Learn to manage time effectively

List of Student Club Activities

1. Music (vocals, instruments, technical, recording, mixing, production, management)
2. Dance (Indian classical, western, jazz, latin, contemporary, folk, production, event management)
3. Theatre (classical, experimental, one-act, street, production, direction, casting, etc.)
4. Arts (fine arts, painting, calligraphy, sketching, caricaturing, etc)
5. Craft (origami, model making, sculpture, pottery, etc)
6. Cooking (home-style, baking, confectionery, Indian, intercontinental, etc.)
7. Graffiti (street, mural, collage, multimedia, etc)
8. Workshops, quizzes, debates, elocution, etc
9. Filmmaking (adventure, drama, film appreciation, documentary, etc)
10. Photography (conventional, immersive (360), landscape, portrait, technical, editing, etc.)
11. College Fests
12. Designing (graphic design, landscape, interior, etc)
13. Competitive coding
14. Recreational sports activities
15. Other club activities organized by student clubs

List of Activities

1. Be the leader of the club and implement the charter, vision and mission of the club
2. Learn from diverse perspectives and experiences
3. Learn to lead the team, design and execute extra-curicular activities
4. Develop management skills through hands on experience
5. Explore different managerial roles and develop competencies

Text Books

1. Small move: big Change (Caroline Arnold)
2. How to Win at College: Surprising Secrets for Success from the Country's Top Students (Cal Newport)

References

1. Making the most of college: Students speak their minds (author - Richard Light)
2. Failing Forward: Turning Mistakes into Stepping Stones for Success (John C Maxwell)
3. The Last Lecture (Randy Pausch)
4. Lean in (Sheryl Sandberg)
5. Youtube- Introduction to various club activities

Course Outcomes

Upon successful completion of the course, student will be able to

- Be the leader of the club and implement the charter, vision and mission of the club
- Learn from diverse perspectives and experiences
- Learn to lead the team, design and execute extra-curricular activities
- Develop management skills through hands on experience
- Explore different managerial roles and develop competencies

DOSL1031: Club Activity – Competitor

L	T	P	S	J	C
0	0	0	2	0	2*

This course encourages and recognizes student members' work in leading the student organizations through various leadership roles. As leaders they work not just to organize events and activities in specific co-curricular and extra-curricular interests, but also lead the teams that form the core members of the clubs. These activities allow students to learn and practice leadership and management skills through real world experience.

Course Objectives

- Create opportunities for students to learn from organizing club activities
- Learn teamwork, leadership, planning and management of events and activities
- Learn to appreciate multiple perspectives, cultures, and individual capabilities
- Learn to manage time effectively

List of Student Club Activities

1. Music (vocals, instruments, technical, recording, mixing, production, management)
2. Dance (Indian classical, western, jazz, latin, contemporary, folk, production, event management)
3. Theatre (classical, experimental, one-act, street, production, direction, casting, etc.)
4. Arts (fine arts, painting, calligraphy, sketching, caricaturing, etc)
5. Craft (origami, model making, sculpture, pottery, etc)
6. Cooking (home-style, baking, confectionery, Indian, intercontinental, etc.)
7. Graffiti (street, mural, collage, multimedia, etc)
8. Workshops, quizzes, debates, elocution, etc
9. Filmmaking (adventure, drama, film appreciation, documentary, etc)
10. Photography (conventional, immersive (360), landscape, portrait, technical, editing, etc.)
11. College Fests
12. Designing (graphic design, landscape, interior, etc)
13. Competitive coding
14. Recreational sports activities
15. Other club activities organized by student clubs

List of Activities

1. Be the leader of the club and implement the charter, vision and mission of the club
2. Learn from diverse perspectives and experiences
3. Learn to lead the team, design and execute extra-curicular activities
4. Develop management skills through hands on experience
5. Explore different managerial roles and develop competencies

Text Books

1. Small move: big Change (Caroline Arnold)
2. How to Win at College: Surprising Secrets for Success from the Country's Top Students (Cal Newport)

References

1. Making the most of college: Students speak their minds (author - Richard Light)
2. Failing Forward: Turning Mistakes into Stepping Stones for Success (John C Maxwell)
3. The Last Lecture (Randy Pausch)
4. Lean in (Sheryl Sandberg)
5. Youtube- Introduction to various club activities

Course Outcomes

Upon successful completion of the course, student will be able to

- Be the leader of the club and implement the charter, vision and mission of the club
- Learn from diverse perspectives and experiences
- Learn to lead the team, design and execute extra-curricular activities
- Develop management skills through hands on experience
- Explore different managerial roles and develop competencies

POLS1001: Indian Constitution and History

L	T	P	S	J	C
2	0	0	0	0	2*

Course Description:
This course analyzes the basic structure and operative dimensions of the Indian Constitution. It explores various aspects of the Indian political and legal system from a historical perspective highlighting the various events that led to the making of the Indian Constitution. The course also deals with various challenges faced by the constitution and its coping mechanisms. Broadly, the students would understand and explain the working of different institutions and political debates ensuing from the operation of the Indian constitution in action.

Course Objectives:
1. To introduce constitutional history of India.
2. To explain the process of making Indian constitution
3. To analyze Fundamental of Rights, Duties and other principles in constitution
4. To create familiarity with political developments which shaped the constitution.

Course Outcomes:

On the successful completion of the course students would be able to:
1. Demonstrate an understanding of the Constitution of India and how constitutional governance is carried out in India
2. Interpret knowledge of the Fundamental Rights and Duties of the Citizens as well as the Obligation of the state towards its citizens
3. Correlate familiarity with key political developments that have shaped the Constitution and amended it from time to time.
4. Equip themselves to take up other courses in law after having done a foundation course on Indian Constitution

Unit I: India as a Nation **6 hrs**
Khilani, S. (2004). *Introduction, The Idea of India*, Chapter 1. New Delhi: Penguin Books, pp. 1-15.
Rowat, D. (1950). 'India: The Making of a Nation', *International Journal, 5*(2), 95-108. doi:10.2307/40194264
Brass, P. (2018). 'Continuities and Discontinuities between pre- and post-Independence India', Chapter 1. *The Politics of Idea since independence*, New Delhi: Cambridge University Press. pp. 1-30.

<u>Module Learning Outcomes</u>

1. Understand ideas of India
2. Explain the story behind making constitution and its future.
3. Articulate the differences between pre and post-colonial governments.

Unit 2: Understanding the Constitution **6 hrs**

Mehta, U.S. (2011). 'Constitutionalism' in *The Oxford Companion to Politics in India*, (ed) by Nirja Gopal Jayal, and Pratap Bhanu Mehta, New Delhi: Oxford University Press. pp. 15-27.
Austin, G. (2016), 'The Constituent Assembly: Microcosm in Action' in *The Indian Constitution: Cornerstone of a Nation*, New Delhi: Oxford University Press, pp. 1-25.
Beteille, Andre (2008): "Constitutional Morality," *Economic and Political Weekly,* Vol 43, Issue No 40
Prahladan, Vivek (2012): "Emergence of the Indian Constitution," *Economic and Political Weekly*, Vol 47, Issue No 07.

Module Learning Outcomes
Understand the concept of constitutionalism. Demonstrate strength or weakness of constitutional morality in India
Evaluate constituent assembly debates in framing Indian Constitution.

Unit 3: The Preamble, Fundamental Rights and Directive Principles of State Policy **6 hrs**

Bhakshi, P.M. (2011). 'Preamble' in *The Constitution of India*, New Delhi: Universal Law. Pp. 1-5.
Laxmikanth, M. (2017). 'Chapter IV: Preamble of the Constitution' in *Indian Polity*, Chennai: McGraw Hills.
Kumar, Virendra (2007): "Basic Structure of The Indian Constitution: Doctrine of Constitutionally Controlled Governance [From Kesavananda Bharati to I.R. Coelho]" *Journal of the Indian Law Institute*, Vol 49, No 3, pp 365-398.
Austin, G (2016), ' ' in *The Indian Constitution: Cornerstone of a Nation*, New Delhi: Oxford University Press, pp.63-105.
Reddy, S (1980). Fundamental Ness of Fundamental Rights and Directive Principles in the Indian Constitution. *Journal of the Indian Law Institute*, 22(3), pp. 399-407.
Bhatia, Gautam (2017): "The Supreme Court's Right to Privacy Judgement," *Economic and Political Weekly*, Vol 52, Issue No 44

Module Learning Outcomes

1. Explain the relationship between 'Preamble' and 'The constitution'.
2. Interpret the key concepts of preamble
3. Analyzes the dynamic nature of Indian constitution
4. Understanding Fundamental Rights
5. Evaluate Directive Principles of State Policy
6. Interpret case studies on Fundamental Rights.

Unit 4: Citizenship **6 hrs**

Jayal, N.G. (2019). 'Reconfiguring citizenship in contemporary India' in *South Asia Journal of South Asian Studies*, pp.33-58.
Roy, Anupama. (2010). 'Chapter I: Enframing the citizen in contemporary times' in *Mapping Citizenship in India*, New Delhi: Oxford University Press.
Das, Veena (2010): "State, Citizenship and the Urban Poor," *Citizenship Studies,* Vol 15, pp 319-333.
Valerian Rodrigues

Module Learning Outcomes

1. Explain different dimensions of citizenship in Indian context
2. Evaluate the basis of citizenship
3. Compare 'claim' and 'status'of citizenship

Unit 5: Separation and Distribution of Powers 6 hrs

Pal, Ruma. (2016). 'Separation of Powers' in *The Oxford Handbook of the Indian Constitution*, (ed) by Sujit Choudhry, Madhav Khosla, and Pratap Bhanu Mehta, Delhi: Oxford University Press.
Bakshi, P. (1956). 'Comparative Law: Separation of Powers in India'. *American Bar Association Journal, 42*(6), 553-595.
Rao, P. (2005). 'Separation of Powers in a Democracy: The Indian Experience'. *Peace Research, 37*(1), 113-122.
Kumar, Ashwani (2019): "Constitutional Rights, Judicial Review and Parliamentary Democracy," *Economic and Political Weekly*, Vol 51, Issue 15
Tillin, Louise. (2015). 'Introduction' in *Indian Federalism*. New Delhi: Oxford University Press. pp. 1-30.
Chakrabarty, Bidyut and Rajendra Kumar Pandey. (2008). *Federalism' in Indian Government and Politics*, New Delhi: Sage Publications. pp. 35-53.
Arora, B. and Kailash, K. K. (2018). 'Beyond Quasi Federalism: Change and Continuity in Indian Federalism', in *Studies in Indian Politics*, pp. 1-7.
Agrawal, Pankhuri (2020): "COVID-19 and dwindling Indian Federalism," *Economic and Political Weekly,* Vol 55, Issue No 26

Module Learning Outcomes

1. Explain the importance of separation of powers in a democracy
2. Understand the relation between three organs of the government
3. Evaluate the system of 'checks and balances'
4. Understand the difference between unitary and federal political systems
5. Critically analyze the Indian model of Federalism
6. Evaluate the distribution of responsibilities between union and state governments.

Recommended Readings:

De, Rohit. (2018). *A People's Constitution – The Everyday Life of Law in the Indian Republic*, USA: Princeton University Press.
Granville Austin, *The Indian Constitution: Cornerstone of a Nation*, Oxford University Press, Oxford, 1966.
Lahoti, R.C. (2004). *Preamble: The Spirit and Backbone of the Constitution of India*. Delhi: Eastern Book Company.
Rajeev Bhargava (ed), *Ethics and Politics of the Indian Constitution*, Oxford University Press, New Delhi, 2008.
Subhash C. Kashyap, *Our Constitution*, National Book Trust, New Delhi, 2011.
Tillin, Louise. (2015). *Indian Federalism*. New Delhi: Oxford University Press.
Zoya Hassan, E. Sridharan and R. Sudarshan (eds), *India's Living Constitution: Ideas, Practices, Controversies*, Permanent Black, New Delhi, 2002.

PHPY1001: Gandhi for the 21st Century

L	T	P	S	J	C
2	0	0	0	0	2*

Course Description

This course provides the students with basic knowledge on Gandhi's early life, transformations in South Africa and his entry into India's national movement. While going through the social-political, economic and educational philosophies of Gandhi, the course analyses how his ideologies are relevant even in the 21st century.

Course Objectives

The objectives of the course are;
1. To provide the students with the basic knowledge on Gandhi's life and his philosophies
2. To understand the early influences and transformations in Gandhi
3. To analyse the role of Gandhi in India's national movement
4. To apply Gandhian Ethics while analysing the contemporary social/political issues
5. To appreciate the conflict resolution techniques put forward by Gandhi and its significance in the current scenario.

Module I : MK Gandhi: Childhood and Education

M K Gandhi, Formative Years (1869-1893): Early childhood - study in England - Indian influences, early Western influences.

Module II: From Mohan to Mahatma-South African Experiences

Gandhi in South Africa (1893-1914): South African Experiences - civil right movements in South Africa - invention of Satyagraha - Phoenix settlement- Tolstoy Farm - experiments in Sarvodaya, education, and sustainable livelihood.

Module III: Gandhi and Indian National Movement

Gandhi and Indian National Movement (1915-1947): Introduction of Satyagraha in Indian soil -non-cooperation movement - call for women's participation - social boycott - Quit-India movement - fighting against un-touchability - Partition of India- independence.

Module IV: Gandhi and Sustainable Development

Gandhian Constructive Programs-Eleven Vows-Sarvodaya-Seven Social Sins-Gandhian Economics and Sustainable Development

Module V: Gandhi and Contemporary Issues

Conflict Resolution Techniques of Gandhi-Ecological Challenges and Gandhian solutions-Gandhian Ethics-An Analysis

Learning Outcomes
1. To understand the life of Gandhi
2. To understand the role of Gandhi in Indian national movement
3. To analyse the origin and significance of Satyagraha
4. To understand the eleven vows of Gandhi which he followed through-out his life.

5. To examine the significance of constructive programs today

Course Outcomes

After the successful completion of the course the students will be able to;
1. Understand the life of Gandhi
2. Appreciate the role of Gandhian non-violence and Satyagraha in India's freedom struggle.
3. Critically examine the philosophy of Gandhi on Education, Sarvodaya, and Satyagraha
4. Analyse the contemporary significance of Gandhian constructive programmes and eleven vows
5. Examine the possible solutions for some of the contemporary challenges like environmental issues, moral degradation and ethical dilemmas.

References

1. Gandhi, M K. (1941). *Constructive Programme*. Ahmadabad: Navjivan Publishing House
2. Gandhi, M. K. (1948). *The Story of My Experiments with Truth*. Ahmadabad: Navjivan Publishing House
3. Gandhi, M K. (1968). *Satyagraha in South Africa*. Ahmadabad: Navjivan Publishing House.
4. Khoshoo, T N (1995). *Mahatma Gandhi: An Apostle of Applied Human Ecology*. New Delhi:TERI
5. Kripalani, J.B. (1970). *Gandhi: His Life and Thought*. New Delhi: Publications Division.
6. Narayan, Rajdeva (2011). *Ecological Perceptions in Gandhism and Marxism*. Muzaffarpur: NISLS
7. Pandey, J. (1998). *Gandhi and 21st Century*. New Delhi: Concept.
8. Weber, Thomas (2007).Gandhi as Disciple and Mentor. New Delhi: CUP

DOSL1041: Community Services - Volunteer

L	T	P	S	J	C
0	0	0	0	2	2*

This course recognizes student participation in Community service activities organized by various student organizations and other Government and non-government organizations that exist for providing service to communities. These activities allow students to develop empathy, citizenship behavior and community values.

Course Objectives

- To help students develop empathy and citizenship behavior
- Enable students to develop an altruistic attitude and community development sensibility
- Allow exploration of community service activities and reflect about these experiences
- Learn to work in small and large teams for achieving community objectives

List of Community Service Activities

1. Community Health Services
2. Swachh Bharat Abhiyan and other Cleanliness drives
3. Tree Plantation and similar environmental conservation initiatives
4. Rain water harvesting awareness and implementation
5. Fundraising and visits to Orphanages, Old-age homes, etc.
6. Health and disease awareness programs
7. Working with NGOs
8. Disaster mitigation and management training and relief work
9. Rural Upliftment projects
10. Campus awareness and action projects (cleanliness, anti-ragging, blood donation, etc)
11. Community investigations and surveys for development research
12. Educational support for underprivileged (remedial classes, coaching, training, etc)
13. Service camps
14. Advocacy and information literacy initiatives
15. Other activities serving local communities

List of Activities

1. Participation in various community service activities
2. Weekly reflection paper
3. Portfolio (on social media using an instagram account)
4. Two learning papers (one per semester)

Text Books

1. Soul of a citizen: living with conviction in Challenging times (author: Paul Rogat Loeb)
2. Community Services intervention: Vera Lloyd

References

1. A path appears: Transforming lives, creating opportunities (Nicholas Kristof and Sheryl WuDunn)
2. The story of My Experiments with Truth (author: M. K. Gandhi)

Course Outcomes

- Experience of volunteering in a variety of Community service activities
- Gaining empathy for lesser privileged sections of society by experience
- Understanding the process of generating community awareness
- Understanding Disaster management and relief through training and experience
- Developing environmental and sustainability awareness

DOSL1051: Community Services - Mobilizer

L	T	P	S	J	C
0	0	0	0	2	2*

This course recognizes student leadership in mobilizing community service activities as members of various student organizations or other Government and non-government organizations that exist for providing service to communities. These activities allow students to develop leadership, management skills, empathy, citizenship behavior and community values.

Course Objectives

- To help students understand leadership in a community environment
- Enable students to develop an altruistic attitude and community development sensibility
- Allow deep understanding of community service through practical experience
- Learn to lead small and large teams for achieving community objectives

List of Community Service Activities

1. Community Health Services
2. Swachh Bharat Abhiyan and other Cleanliness drives
3. Tree Plantation and similar environmental conservation initiatives
4. Rain water harvesting awareness and implementation
5. Fundraising and visits to Orphanages, Old-age homes, etc.
6. Health and disease awareness programs
7. Working with NGOs
8. Disaster mitigation and management training and relief work
9. Rural Upliftment projects
10. Campus awareness and action projects (cleanliness, anti-ragging, blood donation, etc)
11. Community investigations and surveys for development research
12. Educational support for underprivileged (remedial classes, coaching, training, etc)
13. Service camps
14. Advocacy and information literacy initiatives
15. Other activities serving local communities

List of Activities

1. Organizing and leading teams in various community service activities
2. Fortnightly reflection paper
3. Portfolio (on social media using an instagram account)
4. Two learning papers (one per semester)

Text Books

1. Soul of a citizen: living with conviction in Challenging times (author: Paul Rogat Loeb)
2. Community Services intervention: Vera Lloyd

References

1. A path appears: Transforming lives, creating opportunities (Nicholas Kristof and SherylWuDunn)
2. The story of My Experiments with Truth (author: M. K. Gandhi)
3. List of student run and and other Government and non-government community serviceorganizations organizations

Course Outcomes

- Experience of mobilizing and executing Community service activities
- Providing opportunities for community service volunteering for other fellow students
- Understanding the process of mobilizing cash, kind and volunteer support
- Building leadership and management skills
- Building empathy and citizenship behavior

ENVS1001: Environmental Studies

L	T	P	S	J	C
3	0	0	0	0	3*

The course enables the students to adapt eco-centric thinking and actions rather than human-centric thinking on natural resources, their utilization and conservation. The course also focuses on the importance of ecosystems, biodiversity and their degradation led to pollution. This course helps in finding solutions through application of control measures to combat pollution and legal measures to achieve sustainable development.

Course Objectives

1. To impart knowledge on natural resources and its associated problems.
2. To familiarize learners about ecosystem, biodiversity, and their conservation.
3. To introduce learners about environment pollution.
4. To acquaint learners on different social issues such as conservation of water, green building concept.
5. To make learners understand about the present population scenario, its impacts and role of informational technology on environment and human health.
6. To make learners understand about the importance of field visit.

Course Outcomes

After the completion of the course student will be able to

1. List different natural resources and their uses
2. Summarize the structure and function of terrestrial and aquatic ecosystems.
3. Identify causes, effects, and control measures of pollution (air, water & soil).
4. Function of green building concept.
5. Adapt value education

UNIT – I Multidisciplinary nature of environmental studies & Natural Resources: No of Hours: 10

Multidisciplinary nature of environmental studies Definition, scope and importance. Need for public awareness. Natural resources and associated problems. Uses and over exploitation of Forest resources, Water resources, Mineral resources, Food resources, Energy resources. Role of an individual in conservation of natural resources.

Activity:

1. Planting tree saplings
2. Identification of water leakage in house and institute-Rectify or report
3. Observing any one day of a week as Car/bike/vehicle free day.

UNIT – II Ecosystem and biodiversity No of Hours: 10

Ecosystem: Structure components of ecosystem: Biotic and Abiotic components. Functional components of an ecosystem: Food chains, Food webs, Ecological pyramids, Energy flow in the ecosystem (10% law), Ecological succession.

Biodiversity: Definition, Biogeographical classification of India, Values of biodiversity: consumptive use, productive use, social, ethical, aesthetic. Hot-spots of biodiversity. Threats to biodiversity: habitat loss, poaching, man wildlife conflicts. Conservation of biodiversity: In – situ and Ex-situ

Activity”

1. Visit to Zoological Park-Noting different ecosystem
2. Biodiversity register- Flora and fauna in the campus

UNIT – III **Environmental Pollution** No of Hours: 10

Definition Causes, effects, and control measures of: -Air pollution. Water pollution. Soil pollution. Marine pollution. Noise pollution. Nuclear hazards. Solid waste Management: Causes, effects, and control measures. Role of an individual in prevention of pollution. Pollution case studies.

Activity

1. Visit to treatment plant and documentation.
2. Documentation of segregation of solid waste-Dry and Wet

Learning Outcomes:

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

UNIT – IV **Social Issues and the Environment** No of Hours: 10

From Unsustainable to Sustainable development Urban problems related to energy. Water conservation, rainwater harvesting, watershed management. Environmental ethics: Issues and possible solutions. Green building concept.

Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies.

Activity:

1. Observing zero hour at individual level-documentation.
2. Eco friendly idols.
3. Rainwater harvesting-creating storage pits in nearby area.

UNIT – V **Human Population and the Environment and Environment Protection Act and Field work** No of Hours: 10

Population growth, variation among nations. Environment and human health. HIV/AIDS, Human rights. Value Education. Women and Child Welfare. Role of Information Technology in Environment and human health. Environment Legislation. Air (Prevention and Control of Pollution) Act. Water (Prevention and Control of Pollution) Act. Wildlife Protection Act. Environmental Protection Act, Issues involved in enforcement of environmental legislation.

Activity:

1. Visit to a local polluted site-industry/agriculture
2. Identifying diseases due to inappropriate environmental conditions

Text Book(s)

1. Erach Bharucha. Textbook of environmental studies for undergraduates courses-Universities Press, India Private Limited. 2019.
2. Kaushik A and Kaushik C.P. Perspectives in Environmental Studies. New Age International Publishers Edition-VI. 2018.
3. Dave D Katewa S.S. Textbook of Environmental Studies, 2nd Edition. Cengage Learning India. 2012.

Additional Reading

1. Benny Joseph. Textbook of Environmental Studies 3rd edition, McGraw Hill Publishing company limited. 2017.

Reference Book(s):

1. McKinney M.L., Schoch R.M., Yonavjak L. Mincy G. Environmental Science: Systems and Solutions. Jones and Bartlett Publishers. 6th Edition. 2017.
2. Botkin D.B. Environmental Science: Earth as a Living Planet. John Wiley and Sons. 5th edition. 2005.

Journal(s):

1. https://www.tandfonline.com/loi/genv20
2. https://library.lclark.edu/envs/corejournals

Website(s):

https://www.ugc.ac.in/oldpdf/modelcurriculum/env.pdf

From Climate Science to Action | Coursera

	Programme Objectives (POs)												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2												2		
CO2		2				1							2		
CO3			1						1					1	
CO4				2							2				1
CO5	1													1	
CO6					2							1			1

1-Low, 2-Medium and 3-High Correlation

MFST1001: Health & Wellbeing

L	T	P	S	J	C
0	0	2	0	0	1*

The course provides the students a better understanding of the role of a proper diet in maintenance of human health. This course emphasizes the composition of the food, and will help to understand how to exercise, the role of sports and physical fitness in development of a good health. The course also focuses on the importance of emotional well-being and mindfulness. This course helps in teaching the role of yoga in maintenance of physical balance.

Course Objectives

- To provide an understanding of the relationship between food and nutrition
- To emphasize the role of exercise, sports and physical fitness in obtaining a good health
- To explain about the mindfulness and emotional well being
- To teach the role of yoga and meditation in maintaining the body balance

UNIT-I

Understand the relationship between Food and Nutrition and how food composition affects nutritional characteristics. Knowledge about regulatory principles in determining diets and recommended daily allowances. Understand how to create personalised diet/nutrition plans.

UNIT-II

Understand how exercise, activity and sports helps in developing good health. Experiential exposure to the role of proper, specific nutritional interventions along with structured activities on developing proper physical health. Practical exercises and assignments in sports and exercise regimes.

UNIT-III

Introduction to emotional wellbeing and mindfulness. Teaching of mindfulness practices to reduce stress, increase relaxation and improve mental wellbeing.

UNIT-IV

Introduction to Yoga theory and how Yoga helps in maintaining balance in the body. Practice of Yoga and meditation to improve overall emotional and physical balance. Practical yoga exercises and meditation techniques

Course outcomes:

By the end of the course, student will

- Learn the role of nutrition and diet in maintaining a good health
- Will understand how the exercise, sports and physical activities will improve health
- Will learn mindfulness practices for reducing stress
- Will know the importance of yoga and meditation

CLAD2001: Preparation for Campus Placement-1

(Soft Skills 5A)

L	T	P	S	J	C
0	0	2	0	0	1

Course Description:

The course addresses all relevant areas related to campus placements and readies them to ace their upcoming/ ongoing recruitment drives. Specifically, it focuses on students' career preparedness, interview skills, test preparedness, etc.

Course Objectives:

Prepare the students for their upcoming/ ongoing campus recruitment drives.

1. Career Preparedness: Resume & Cover Letter Writing, Interview Skills: Elevator Pitch, Making the First Impression, Being Other-Oriented, Being Positive and Curious, communicating with Confidence and Poise, Frequently Asked Questions & How to Answer Them, Pitfalls to Avoid, Etc. Etiquette: Hygiene, Courtesy, Culture differences, Workplace, use of cell phone, Profanity, Slang, Protocol.

2. Verbal Ability: Practising Reading Comprehension, Error Detection, Sentence Completion, MCQs, FIBs, Para jumbles, Cloze Test, Critical Reasoning.

3. Quantitative Aptitude: Number Systems, Algebra, Geometry, Data Handling, Data Sufficiency, Word Problems

4. Reasoning: Logical and Verbal Reasoning

Course Outcomes:

1. Write a power resume and covering letter
2. Answer interview questions with confidence and poise
3. Exhibit appropriate social mannerisms in interviews
4. Solve placement test questions on verbal ability, quantitative aptitude and reasoning

References:

1. Verbal Ability & Reading Comprehension by Arun Sharma and Meenakshi Upadhyay
2. Study material for CAT, SAT, GRE, GMAT by TIME, CareerLauncher and IMS etc.
3. Quantitative Aptitude by R S Agarwal S Chand Publications
4. Quantitative Aptitude by Pearson Publications

CLAD2011: Preparation for Higher Education (GRE/ GMAT)-1 (Soft Skills 5B)

L	T	P	S	J	C
0	0	2	0	0	1

Course Description:

1. The course offers a special track for students who aspire to go abroad in pursuit of their higher education for which a GRE/ GMAT score is a prerequisite. It covers all four topical areas of these tests and includes fully solved mock tests as well.

Course Objectives:

1. Prepare the students to solve questions from all four broad areas of GRE/ GMAT
2. Orient the students for GRE/ GMAT through mock tests

1. Verbal Reasoning: Reading Comprehension, Sentence Equivalence, Text Completion, Sentence Correction, Critical Reasoning

2. Quantitative Reasoning: Arithmetic, Algebra, Geometry, Data Analysis

3. Analytical Writing Assessment: Issue/ Argument

4. Integrated Reasoning

Course Outcomes:

1. Solve questions from all four broad areas of GRE/ GMAT
2. Practice answering several mock tests

References:

1. Verbal Ability & Reading Comprehension by Arun Sharma and Meenakshi Upadhyay
2. Study material for CAT, SAT, GRE, GMAT by TIME, CareerLauncher and IMS etc.
3. Quantitative Aptitude by R S Agarwal S Chand Publications
4. Quantitative Aptitude by Pearson Publications

CLAD2021: Preparation for CAT/ MAT - 1
(Soft Skills 5C)

L	T	P	S	J	C
0	0	2	0	0	1

Course Description:

The course offers a special track for UG students who aspire to go for higher education in business management in India for which cracking CAT/ MAT/ other related test is mandatory. It covers all four topical areas of these tests and includes fully solved mock tests as well.

Course Objectives:

1. Prepare the students to solve questions from all four relevant areas of CAT/ XAT/ MAT, etc.
2. Orient the students for CAT/ XAT, etc. through mock tests

1. Quantitative Ability: Arithmetic, Algebra, Geometry, Mensuration, Calculus, Trigonometry

2. Data Interpretation: Data Interpretation and Data Sufficiency

3. Logical Reasoning: Data Management, Deductions, Verbal Reasoning and Non-Verbal Reasoning
4. Verbal Ability: Critical Reasoning, Sentence Correction, Para Completion, Para Jumbles, Reading Comprehension

Course Outcomes:

1. Solve questions from all four relevant areas of CAT/ MAT as listed above
2. Practice test-cracking techniques through relevant mock tests

References:

1. Verbal Ability & Reading Comprehension by Arun Sharma and Meenakshi Upadhyay

2. Study material for CAT, SAT, GRE, GMAT by TIME, CareerLauncher and IMS etc.
3. Quantitative Aptitude by R S Agarwal S Chand Publications
4. Quantitative Aptitude by Pearson Publications

CLAD2031: Preparation for Campus Placement-2

(Soft Skills 6A)

L	T	P	S	J	C
0	0	2	0	0	1

Course Description:

This course builds on the previous course and focuses on all four major areas of campus placements, including career preparedness, mock interviews, verbal ability, quantitative aptitude and logical reasoning.

Course Objectives:

1. To comprehensively prepare all eligible and aspiring students for landing their dream jobs.
2. To sharpen the test-taking skills in all four major areas of all campus drives

1. Career Preparedness II: Mock Interviews, Feedback and Placement Readiness

2. Verbal Ability II: Practising Reading Comprehension, Error Detection, Sentence Completion, MCQs, FIBs, Para jumbles, Cloze Test, Critical Reasoning

3. Quantitative Aptitude II: Number Systems, Algebra, Geometry, Data Handling, Data Sufficiency, Word Problems

4. Reasoning II: Logical and Verbal Reasoning

Course Outcomes:

1. Demonstrate career preparedness and confidence in tackling campus interviews
2. Solve placement test questions of a higher difficulty level in verbal ability, quantitative aptitude and logical reasoning.
3. Practice test-taking skills by solving relevant questions accurately and within time.

References:

1. Verbal Ability & Reading Comprehension by Arun Sharma and Meenakshi Upadhyay

2. Study material for CAT, SAT, GRE, GMAT by TIME, CareerLauncher and IMS etc.
3. Quantitative Aptitude by R S Agarwal S Chand Publications
4. Quantitative Aptitude by Pearson Publications

CLAD2041: Preparation for Higher Education (GRE/ GMAT)-2
(Soft Skills 6B)

L	T	P	S	J	C
0	0	2	0	0	1

Course Description:

1. The course offers a special track for students who aspire to go abroad in pursuit of their higher education for which a GRE/ GMAT score is a prerequisite. It covers all four topical areas of these tests at a higher difficulty-level and includes fully solved mock tests as well.

Course Objectives:

1. Prepare the students to solve higher level questions from all four broad areas of GRE/ GMAT
2. Orient the students for GRE/ GMAT through mock tests

1. Verbal Reasoning II: Reading Comprehension, Sentence Equivalence, Text Completion, Sentence Correction, Critical Reasoning

2. Quantitative Reasoning II: Arithmetic, Algebra, Geometry, Data Analysis

3. Analytical Writing Assessment II: Issue/ Argument

4. Integrated Reasoning II

Course Outcomes:

1. Solve higher level questions from all four broad areas of GRE/ GMAT
2. Practice answering several mock tests

References:

1. Verbal Ability & Reading Comprehension by Arun Sharma and Meenakshi Upadhyay
2. Study material for CAT, SAT, GRE, GMAT by TIME, CareerLauncher and IMS etc.
3. Quantitative Aptitude by R S Agarwal S Chand Publications
4. Quantitative Aptitude by Pearson Publications

CLAD2051: Preparation for CAT/ MAT - 2
(Soft Skills 6C)

L	T	P	S	J	C
0	0	2	0	0	1

Course Description:

The course offers a special track for UG students who aspire to go for higher education in business management in India for which cracking CAT/ MAT/ other related test is mandatory. It covers all four topical areas of these tests at a higher level of difficulty and includes fully solved mock tests as well.

Course Objectives:

1. Prepare the students to solve all types of questions from all four relevant areas of CAT/ XAT/ MAT, etc.

1. Quantitative Ability II: Arithmetic, Algebra, Geometry, Mensuration, Calculus, Trigonometry
2. Data Interpretation II: Data Interpretation and Data Sufficiency
3. Logical Reasoning II: Data Management, Deductions, Verbal Reasoning and Non-Verbal Reasoning
4. Verbal Ability II: Critical Reasoning, Sentence Correction, Para Completion, Para Jumbles, Reading Comprehension

Course Outcomes:

1. Solve higher difficulty level questions from all four relevant areas of CAT/ MAT as listed above
2. Practice test-cracking techniques through relevant mock tests

References:

1. Verbal Ability & Reading Comprehension by Arun Sharma and Meenakshi Upadhyay
2. Study material for CAT, SAT, GRE, GMAT by TIME, CareerLauncher and IMS etc.
3. Quantitative Aptitude by R S Agarwal S Chand Publications
4. Quantitative Aptitude by Pearson Publications

FINA3001: Personal Financial Planning

L	T	P	S	J	C
0	0	2	0	0	1*

Course Overview

Personal Financial Planning is one of the most significant factors in our lives. It is essential that funds are available as and when required at various stages of life. Unavailability of funds at critical stages of our life leads to financial distress and leads to many medical and non-medical problems. There are certain planned and unplanned events in our life. On the one hand, education of our children, their marriage, our retirement etc. are some of the planned events of our life, but at the same time, some medical urgency, accident or death of an earning member might be some unplanned events. Many of these events are beyond our control, but the availability of funds can be planned to avoid any financial distress. In other words, we cannot stop the rain but can plan for an umbrella.
This course looks at the many challenges an individual faces in a complex financial environment and the rising uncertainties of one's life. It focuses on achieving long-term financial comfort of individual and family through goal setting, developing financial and life strategies, acquiring personal financial planning knowledge and managing risk throughout one's life.

Course Objectives:

1. To build students' ability to plan for long-term financial comfort of individual and family through goal setting, developing financial and life strategies.
2. To provide students with knowledge on terms, techniques to evaluate investment avenues.
3. To build the skill set of the student to enable them to file their tax returns.

Course Outcome:
1. Describe the financial planning process and application of time value of money
2. Application of life and non-life insurance products in financial planning
3. Understand the investment avenues and analysis of investment returns
4. Understand the retirement planning and its application
5. Describe and analysis the Tax Planning

Unit 1: Basics of Financial Planning
Financial Planning Meaning, Need, Objectives, Financial Planning Process, Time Value of Money and its application using excel (NP)

Unit 2: Risk and Insurance Management
Need for insurance, Requirement of insurance interest, Role of insurance in personal finance, Steps in insurance planning, Life and Non-life insurance products, Life insurance needs analysis (NP)

Unit 3: Investment Products and Measuring Investment Returns
Investment Products: Small Saving Instruments, Fixed Income Instruments, Alternate

Investments, Direct Equity
Measuring Investment Returns: Understanding Return and its concept, Compounding concept, Real vs Nominal Rate of Return, Tax Adjusted Return, Risk-Adjusted Return (NP)

Unit 4: Retirement Planning
Introduction to the retirement planning process, estimating retirement corpus, Determining the retirement corpus, Retirement Products (NP)

Unit: 5 Tax Planning
Income Tax: Income tax principles: Heads of Incomes, Exemptions and Deductions, Types of Assesses, Rates of Taxation, Obligations for Filing and Reporting, Tax aspects of Investment Products, Wealth Tax

Text Books

1. National Institute of Securities Management (NISM) Module 1 & XA
2. Madhu Sinha, Financial Planning, 2 Edition, McGraw Hill India
3. Simplified Financial Management by Vinay Bhagwat, The Times Group

Reference Books

1. Personal Financial Planning (Wealth Management) by S Murali and K R Subbakrishna, Himalaya Publishing House.
2. Mishra K.C., Doss S, (2009). Basics of Personal Financial Planning 1e. National Insurance Academy, New Delhi: Cengage Learning.
3. Risk Analysis, Insurance and Retirement Planning by Indian Institute of Banking and Finance.

PHYS1001: PHYSICS

L	T	P	C
3	0	2	4

This course is designed with fundamentals of electromagnetism and properties of materials for advanced courses in their respective engineering branches. It introduces electromagnetic theory with relevant mathematical tools, optical fibres and their propagation characteristics, properties of dielectric and magnetic materials. It also introduces principles of semiconductors and some widely used semiconductor devices for various applications.

Course Objectives

- To introduce mathematical principles to estimate forces, fields and waves.
- To familiarize students with electromagnetics in modern communication systems.
- To impart knowledge concerning the electrical behaviour of dielectric materials.
- To demonstrate the properties of magnets.
- To introduce semiconductor physics and devices.

UNIT I: Basics of Electromagnetics 9 L

Electrostatic field: Coulomb's law and Gauss 'law, derivation of Coulombs law from Gauss' law, applications of Gauss' law (line charge, thin sheet of charge and solid charged sphere), Gauss' law of electrostatics in dielectric medium, divergence and curl of electric fields, electric potential, relation between potential and force, Poisson's and Laplace equations.

Magnetostatic field: Biot–Savarts' law, divergence and curl of magnetic fields, Faraday's and Ampere's laws in integral and differential form, displacement current, continuity equation, Maxwell's equations.

Learning Outcomes:

- apply Coulomb's and Gauss' laws to electric field configurations from charge distributions (L3)
- apply the Biot-Savarts' law to derive magnetostatic field distributions (L3)
- use vector calculus to describe electromagnetic phenomena(L2)
- relate the law of conservation of charge to continuity equation(L3)
- illustrate the Maxwell's equations, Maxwell's displacement current and correction of Ampere's law(L2)

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT II: Fiber Optics 7 L

Introduction, advantages of optical fibers, principle and structure, acceptance angle, numerical aperture, modes of propagation, classification of fibers, fiber optic communication, importance of V-number, fiber optic sensors (Temperature, displacement and force), applications.

Learning Outcomes:

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

- apply the principle of propagation of light in optical fibers(L3)
- explain the working and classification of optical fibers(L2)
- analyse propagation of light through optical fibers based on the concept of modes (L4)
- summarize applications of optical fibers in medical, communication and other fields(L2)

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT III: Dielectric, Magnetic and superconducting Materials 10 L

Dielectric materials: Introduction, electric polarization, dielectric polarizability, susceptibility and dielectric constant, types of polarizations (qualitative treatment only). Magnetic materials: Introduction, magnetic dipole moment, magnetization, magnetic susceptibility and permeability, origin of permanent magnetic moment, classification of magnetic materials, Weiss theory of ferromagnetism (qualitative), domain theory, hysteresis, soft and hard magnetic materials.

Superconductivity: definition –Meissner effect –type I & II superconductors –BCS theory (qualitative) –high temperature superconductors –Josephson effects applications.

Learning Outcomes:

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

- explain the concept of dielectric constant and polarization in dielectric materials (L2)
- interpret dielectric loss, Lorentz field and Claussius-Mosotti relation (L2)
- classify the magnetic materials(L2)
- explain the phenomenon of hysteresis for a ferromagnetic material and summarize the properties of hard and soft magnetic materials (L2)
- understand the concept of superconductivity (L2)

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT IV: Semiconductor Physics 8 L

Introduction, origin of energy band, intrinsic and extrinsic semiconductors, mechanism of conduction in intrinsic semiconductors, generation and recombination, carrier concentration in intrinsic semiconductors, variation of intrinsic carrier concentration with temperature, n-type and p-type semiconductors, carrier concentration in n-type and p- type semiconductors, Drift and diffusion currents in semiconductors.

Learning Outcomes:

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

- outline the properties of semiconductors(L2)
- interpret expressions for carrier concentration in intrinsic and extrinsic semiconductors(L2)
- assess the variation of carrier concentration in semiconductors with temperature (L5)

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT V: Semiconductor Devices 8 L

Zener Diode, Tunnel diode, Hall effect and its applications, magnetoresistance, p-n junction layer formation and V-I characteristics, direct and indirect band gap semiconductors, construction and working of photodiode, LED, solar cell.

Learning Outcomes:

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

- explain the drift and diffusion currents and formation of junction layer (L2)
- state Einstein's relations(L1)
- explain Hall effect and its applications(L3)
- illustrateandinterprettheV-Icharacteristicsofap-njunctiondiode(L2)
- describe applications of p-n junction diodes in photodiodes, LEDs and solar cells (L3).

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

Text Book(s)

1. David J.Griffiths, “Introduction to Electrodynamics”, 4/e, Pearson Education, 2014.
2. Charles Kittel, “Introduction to Solid State Physics”, Wiley Publications, 2011.
3. M. N. Avadhanulu, P.G. Kshirsagar, “A Text book of Engineering Physics”, 11/e, S. Chand Publications, 2019.

Reference book(s)

1. Principles of Physics, 10ed, ISV, Jearl Walker, David Halliday, Robert Resnick, Wiley India.
2. Gerd Keiser, “Optical Fiber Communications”, 4/e, Tata Mc Graw Hill, 2008.
3. S.O.Pillai, “Solid StatePhysics”, 8/e, New Age International, 2018.
4. S.M. Sze, “Semiconductor Devices-Physics and Technology” , Wiley, 2008.

Journal(s):

1. https://aapt.scitation.org/doi/abs/10.1119/1.3317450
2. https://aapt.scitation.org/doi/full/10.1119/1.5144798
3. https://aapt.scitation.org/doi/abs/10.1119/1.1511591

PHYSICS LABORATORY

List of Experiments

1. To determine the magnetic field along the axis of a circular coil carrying current.
2. To determine the numerical aperture of a given optical fiber and hence to find its acceptance angle
3. To determine magnetic susceptibility by Quincke’s tube method
4. To determine the Hall coefficient using Hall effect experiment
5. To determine the resistivity of semiconductor by Four probe method
6. To determine the energy gap of a semiconductor.
7. To study the characteristics of PN Junction diode.
8. To study magnetic hysteresis loop (B-H curve).
9. To determine the dielectric constant of a substance by resonance method.
10. To determine hysteresis loss by CRO.
11. To study the characteristics of Photodiode
12. To study the characteristics of Solar Cell
13. To study the characteristics of Zener diode
14. To study the resonance of LCR circuit

Text Book:

1. S. Balasubramanian, M.N. Srinivasan “A Text book of Practical Physics”- S Chand Publishers,2017

PHYS1031: MECHANICS AND PROPERTIES OF MATTER

L	T	P	C
3	1	0	4

This course is designed for students of Aerospace, Civil and Mechanical Engineering. It introduces fundamentals of elasticity and thermal properties – the essentials for understanding the behaviour of materials. Mechanics of solids is taught to acquaint them with the behaviour of rigid objects. An introduction to sensors will be useful for all the branches as an application of modern technology.

Course Objectives

- To acquaint the basic concepts of sound waves and principles in acoustic design.
- To introduce the concepts of elasticity, strain hardening and failure in materials and impart the relation between stress and strain.
- To impart the phenomenon of heat transfer so as to understand a wide variety of practical engineering problems.
- To demonstrate the use of Newton's laws of motion for understanding the mechanics of a particle.
- To explain the working principle and construction of different types of sensors.

UNIT-I Mechanics: 10 Hours

Basic laws of vectors and scalars; Rotational frames; Conservative and non-conservative forces; F = - grad V; Central forces; Elliptical, parabolic and hyperbolic orbits; Noninertial frames of reference; Centripetal acceleration; Harmonic oscillator; Damped harmonic motion; Forced oscillations and resonance. Degrees of freedom.

Learning Outcomes:

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

- Explain forces and moments in mechanical systems using scalar and vector techniques L2
- interpret the equation of motion of a rigid rotating body (torque on a rigid body) L3
- apply the Newton's second law for inertial and non inertial frame of reference L3
- summarize harmonic motion in undamped, damped and forced oscillations L2

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT-II Elasticity 8 Hours

Concepts of elasticity and plasticity, stress and strain, Hooke's law, different moduli of elasticity, Poisson's ratio, strain energy, stress-strain diagram, elastic behavior of a material, factors affecting elasticity, relation between different moduli of elasticity, determination of elastic moduli.

Learning Outcomes:

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

- explain the basic concepts of elasticity, plasticity, strain hardening and failure in materials L2
- determine graphically a material's mechanical properties in terms of its one dimensional stress-strain curve L2
- derive the generalized Hooke's law by recognizing the basic stress-strain response of isotropic materials L3
- Define several elastic constants and determine the relationship between them L1
- evaluate strain energy under different loadings L3

Pedagogy tools: Blended learning,Case let, video lectures, self-reading

UNIT - III Thermal Properties 10 Hours

Transfer of heat energy; Thermal expansion of solids and liquids; Expansion joints -bimetallic strips; Thermal conduction, convection and radiation and their fundamental laws; Heat conductions in solids; Thermal conductivity - Forbe's and Lee's disc method: theory and experiment; Applications (qualitative only): heat exchangers, refrigerators, ovens and solar water heaters.

Learning Outcomes:

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

- explain the process of thermal expansion in solids and liquids L3
- distinguish fundamental laws related to conduction, convection and radiation of heat L1
- determine the thermal conductivity of a material by Forbes and Lee’s disc method L4
- summarize the working of heat exchangers, refrigerators, ovens and solar water heaters L2

UNIT - IV Acoustics 8 Hours

Characteristics of sound waves; Weber-Fechner Law; Absorption coefficient, determination of absorption coefficient; Reverberation time; Sabine's formula, derivation of Sabine's formula using growth and decay method; Intensity of sound; Acoustics of buildings, Acoustic requirements of a good auditorium.

Learning Outcomes:

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

- explain the basic concepts in acoustics and describe Weber-Fechner Law L2
- determine absorption coefficient and reverberation time L3
- derive Sabine’s formula using growth and decay method L4
- solve problems involving the intensity of a sound wave L4
- summarize the principles of acoustics in designing an acoustically good auditorium L3

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT– V: Sensors 9 Hours

Sensors (qualitative description only); Different types of sensors and applications; Strain and pressure sensors- Piezoelectric, magnetostrictive sensors; Fibre optic methods of pressure sensing; Temperature sensor - bimetallic strip, pyroelectric detectors; Hall-effect sensor; Smoke and fire detectors.

Learning Outcomes:

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

- describe the principle of strain and pressure sensors L1
- explain the principle and working of magnetostrictive and piezoelectric sensors L3
- illustrate the fibre optic methods of pressure sensing L3
- infer the functioning of temperature sensors like bimetallic strip and pyroelectric detectors L2
- outline the principle and working of Hall-effect sensor, smoke and fire detectors L2

Text Book(s)

1. D.Kleppner and Robert Kolenkow"An Introduction to Mechanics- II" Cambridge University Press,2015.
2. M.N. Avadhanulu & T.V.S. Arun Murthy, S Chand A Textbook of Engineering Physics, Volume-I 2018.
3. Ian R Sinclair, Sensor and Transducers 3/e,Elsevier (Newnes), 2001.

Reference Book(s)

1. M K Varma, "Introduction to Mechanics"-Universities Press, 2015
2. Prithwiraj Purkait, Budhaditya Biswas and Chiranjib Koley, Chapter 11 Sensors and Transducers, Electrical and Electronics Measurements and Instrumentation, 1/e., McGraw Hill Education (India) Private Limited, 2013.

Course Outcomes:

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

- describe the fundamental principles of acoustics with emphasis on physical mechanisms, law and relationships L1
- apply the concepts of strain, internal force, stress and equilibrium to deformation of solids L3
- explain the fundamental theory for the analysis of heat transfer processess in solids and liquids and to apply basic principles of heat transfer in design of refrigerators and heaters L4
- estimate forces and moments in mechanical systems using scalar and vector techniques L4
- outline the basic principle and operation of different types of sensors L2

PHYS1011: PRINCIPLES OF QUANTUM MECHANICS

L	T	P	C
3	1	0	4

This course is designed with principles of Quantum mechanics for advanced courses in their respective engineering branches. It introduces Quantum mechanics with relevant mathematical tools and provides a basis for further study of quantum mechanics. It also introduces basics of Qubits for Quantum computing applications.

Course Objectives

- To introduce the basic principles of quantum mechanics.
- To introduce wave equation and significance of wave function.
- To teach solving the Schrödinger's equation for spinless particles moving in one-dimensional potential.
- To develop an understanding of concepts of angular momentum.
- To introduce Dirac bra-ket formalism and the concept of QUBITs.

UNIT – I: Introduction to Quantum Physics (10 Hours)

Introduction, Classical Mechanics vs Quantum Mechanics, Planck's quantum theory (qualitative), Photo-electric effect. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them, Wave-particle duality, Heisenberg uncertainty principle: ground state energy of hydrogen atom.

Learning Outcomes:

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

- Get a grasp on the elementary aspects of energy and momentum of a photon and de Broglie wavelength of a particle.
- Know about the uncertainty principle for position and momentum and for energy and time.
- To study the basic principles of quantum mechanics

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT – II: Properties of Matter Waves (8 Hours)

Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization.

Learning Outcomes:

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

- understand the significance of Schrodinger's time independent wave equation.
- explain the operator formulation of quantum mechanics.
- learn the concept of wave function

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT – III: Quantum Tunneling (8 Hours)

One dimensional infinitely rigid box-energy eigenvalues and eigenfunctions, normalization; Quantum dot as example; Quantum mechanical tunnelling in one dimensional rectangular potential barrier, 1D linear harmonic oscillator (no derivation required, only eigen function, eigen values and zero-point energy).

Learning Outcomes:

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

- Derive wave functions with reflection and transmission coefficients
- The concept of quantum mechanical tunneling
- solve time-independent Schrödinger equation for simple potentials

Pedagogy tools: Blended learning,Case let, video lectures, self-reading

UNIT - IV Quantum Properties of Electrons (9 Hours)

Electron angular momentum, angular momentum operator, Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect, Stark Effect, Gyromagnetic Ratio and Bohr Magneton (qualitative)

Learning Outcomes:

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

- understand spin magnetic moment and total angular momentum
- relate the eigenvalue problems for energy, momentum and angular momentum explain the idea of spin
- explain the interaction between spin of electron and magnetic field
- understand the interaction between electron and electric field

Pedagogy tools: Blended learning,Case let, video lectures, self-reading

UNIT – V: Qubits for Quantum Computing (10 Hours)

Introduction to Dirac Bra-Ket notation, Introduction to Pauli spin matrices, Quantum Superposition, Interference, Quantum Measurement, Decoherence, Entanglement, Bloch sphere, Qubits, and multiple qubits, Qubits Vs classical bits, representation of a qubit probability.

Learning Outcomes:

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

- apply Bra-Ket notation in obtaining eigen values
- understand quantum entanglement
- describe the fundamentals of the quantum computing

Pedagogy tools: Blended learning,Case let, video lectures, self-reading

Textbook(s):

1. Quantum Mechanics, G. Aruldhas, 2ndEdn. 2002, PHI Learning of India.
2. Quantum Mechanics, Satya Prakash, 2016, Pragati Prakashan.
3. Quantum Computing for Everyone, Chris Bernhardt, 2019, The MIT Press,

Reference Book(s):

1. Introduction to Quantum Mechanics, D.J. Griffith, 2ndEd. 2005, Pearson Education.
2. Quantum Computing: An Applied Approach, Jack D. Hidary, 2019,

Springer Journal(s):

1. https://aapt.scitation.org/doi/full/10.1119/1.4897588
2. https://aapt.scitation.org/doi/full/10.1119/1.3639154

Websites:

1. https://www.intechopen.com/online-first/73811
2. https://www.quantum-inspire.com/kbase/what-is-a-qubit/

PHYS1021: PHYSICS OF SEMICONDUCTING DEVICES

L	T	P	C
3	1	0	4

This course is designed with fundamentals of electromagnetism and properties of materials for advanced courses in their respective engineering branches. It introduces electromagnetic theory with relevant mathematical tools, optical fibers and their propagation characteristics, properties of dielectric and magnetic materials. It also introduces principles of semiconductors and some widely used semiconductor devices for various applications.

Course Objectives

- To introduce nature light and its properties.
- To familiarize students with different semiconductors and its energy band gaps.
- To introduce semiconductor physics and devices.
- To impart knowledge about the semiconducting optical devices.
- To demonstrate the properties of different semiconducting optical devices.

UNIT I Elements of light **(8 hours)**

Nature of light, Light sources, Black body, Colour temperature, Units of light, Radio metric and photometric units, Light propagation in media and waveguides, Electro-optic effects. Overview of luminescence: Photoluminescence, Cathodoluminescence, Electroluminescence, Injection-luminescence.

Learning Outcomes:

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

- Understanding the dual nature of light L2
- Understanding different law for energy spectrum emitted by black body. L3
- To explain the concepts of electro-optics effects L1
- To summarize the overview of different luminescence L2

UNIT II: Semiconductor Materials **(10 hours)**

Free electron theory of metals, Density of states in 1D, 2D, and 3D, Bloch's theorem for particles in a periodic potential, Energy band diagrams, Kronig-Penny model (to introduce origin of band gap), Energy bands in solids, E-k diagram, Direct and indirect bandgaps, Types of electronic materials: metals, semiconductors, and insulators, Occupation probability, Fermi level, Effective mass.

Learning Outcomes:

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

- Outline the properties of semiconductors L2
- Know the bands structure of metals and semiconductors L3
- Understand the electronic structure of interfaces between different types of materials L2
- To determine the different band gaps of direct and indirect band gap materials L5
- To explain the occupation probability and Fermi level variation in different electronic materials L1

UNIT III: Light-semiconductor interaction (10 hours)

Optical transitions in bulk semiconductors: absorption, spontaneous emission, and stimulated emission; Einstein coefficients, Population inversion, application in semiconductor Lasers; Transition rates (Fermi's golden rule), Optical loss and gain; Photovoltaic effect.

Learning Outcomes:

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

- To summarize the optical transition in bulk semiconductors L2
- To explain the concepts of absorption, spontaneous emission and stimulated emission L1
- To outline the population inversion in semiconductor lasers L2
- To evaluate the transition rates and optical loss and gain in materials L5

UNIT IV: Solar cells and Photovoltaic devices: (9 hours)

Charge carrier generation and recombination, p-n junction model and depletion capacitance, Current voltage characteristics in dark and Light, Device Physics of Solar Cells, Principle of solar energy conversion, Conversion efficiency, Type of solar cells in use: Dye Sensitized Solar Cells, Thin film solar cells.

Learning Outcomes:

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

- Outline the properties of semiconductors L2
- Know about the interaction of light with materials and its optical properties L3
- Illustrate and interpret the voltage and current characteristics of p-n junction diodes model L1
- Explain the conduction mechanism in semiconducting and optical devices. L5
- To describe the applications of p-n junction diodes in types of solar cells L3

UNIT V: Semiconductor devices (8 hours)

Radiative recombination devices: Light-emitting diodes (LED), Organic Light Emitting Diodes (OLED) and its types, Photoelectric devices: Photodiodes. Photoconducting devices: Photodetectors and photoconductors, Photoresistors, Photo transistors, Stimulated emission devices: Injection laser diodes, Quantum cascade lasers.

Learning Outcomes:

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

- describe applications of light emitting diodes and its radiative recombination process L2
- explain the concepts of photoconductive devices and its applications in different devices L3
- to define the concepts of Photodetectors and photoconductors, Photoresistors, Photo transistors, L1
- to access the variation of stimulated emission in injection and quantum lasers L5

Text Books:

1. Schubert, E., Light-Emitting Diodes, 2/e, Cambridge: Cambridge University Press, 2006.

2. Physics of Solar Cells: From Basic Principles to Advanced Concepts, 3rd Edition Peter Würfel, UliWürfel (2016) Wiley.
3. Solid State Physics, Neil W. Ashcroft, N. David Mermin (2003) Cengage Learning India

Reference Books:

1. Quantum Cascade Lasers by Vasilios N. Stavrou: https://www.intechopen.com/books/5389.
2. Optoelectronic materials and device concepts; Manijeh Razeghi, SPIE, 1991
3. Introduction to Organic Electronic and Optoelectronic Materials and Devices; Sun and Dalton, CRC Press, 2008.
4. Semiconductor Physics and Devices, 3ed, An Indian Adaptation, S. M. Sze, M. K. Lee, Wiley India.
5. Semiconductor optoelectronics; Jasprit Singh, McGraw-Hill, 1995.

Course Outcomes

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

- Outline the properties of semiconductors L2
- explain the occupation probability and Fermi level variation in different electronic materials L1
- Know about the interaction of light with materials and its optical properties L3
- Explain the conduction mechanism in semiconducting and optical devices. L5

PHYS1041: MECHANICS AND MODERN PHYSICS

L	T	P	C
3	1	0	4

This course designed for students of Biotechnology to impart principles of Newtonian mechanics will help the students in understanding the oscillatory behavior of materials. It also introduces fundamentals of quantum mechanics – the essentials for understanding the behavior of properties of materials. Fundamentals of optics and electromagnetism in understanding the use in spectroscopy. An introduction to sensors will be useful for all the branches as an application of modern technology.

Course Objectives

- To impart knowledge on damped and forced oscillations.
- To familiarize students with the concepts of quantum mechanics
- To impart knowledge concerning the wave properties of electromagnetic waves
- To familiarize the students about the Maxwell's equations and its propagation
- To outline the principles and working of few common sensing devices

UNIT - I Fundamentals of Dynamics and Oscillations 10 Hours

Fundamentals of Dynamics: Reference frames. Inertial frames; Galilean transformations; Galilean invariance. Review of Newton's Laws of Motion.

Oscillations: SHM, Simple Harmonic Oscillations. Differential equation of SHM and its solution. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor

Learning Outcomes:

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

- Differentiate between inertial and non-inertial frames of reference
- Solve the differential equation of simple harmonic oscillator
- Distinguish between forced and damped oscillators
- Estimate the resonance and its properties
- Describe the Newton's laws of motion

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

UNIT - II Modern Physics (Quantum Physics) 8 Hours

Introduction, matter waves and its properties, Davisson-Germer experiment, GP Thomson experiment, Heisenberg's uncertainty principle, Schrodinger's time independent wave equation, physical significance of wave function, particle in a one-dimensional infinite well, rectangular potential barrier (transmission coefficient), band theory of solids (qualitative), distinction between metals, insulators and semiconductors, introduction to Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstien statistics.

Learning Outcomes:

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

- Get a grasp on the elementary aspects of energy and momentum of a photon and de Broglie wavelength of a particle.
- Know about the uncertainty principle for position and momentum and for energy and time.

- Understand the significance of Schrodinger's time independent wave equation and apply it to a restricted particle.
- Derive wave functions with reflection and transmission coefficients.
- Differentiate between the Maxwell-Bolzmann, Fermi-Dirac and Bose-Einstien statistics

Pedagogy tools: Blended learning,Case let, video lectures, self-reading

UNIT – III: Optics 10 Hours

Interference: Introduction, interference in thin films due to reflected light: interference in parallel-sided film and wedge-shaped film, Newton's rings. Diffraction: Introduction; Fraunhofer diffraction at single slit (qualitative only), diffraction due to N-slits (diffraction grating) (qualitative only), determination of wavelength of light with a plane transmission grating.

Polarisation: Introduction; Double refraction –double refraction in calcite crystal, negative and positive crystals, Nicol's prism, Retarders (quarter and half¬wave plates).

Learning Outcomes:

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

- Develop the ability to determine the conditions for constructive and destructive interference
- Figure out the position and intensity variation of the dark fringes in single-slit diffraction (Fraunhoffer Diffraction).
- Acquire a basic understanding of diffraction gratings with dispersive nature.
- Comprehend the concepts and meaning of Polarization.
- Know about polarization of light, polarizer and methods of producing polarized light.

Pedagogy tools: Blended learning,Case let, video lectures, self-reading

UNIT – IV: Maxwell`s equations and Electromagnetic wave propagation 8 Hours

Maxwell's equations (both differential and integral forms) and its physical significance, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization of EM waves.

Learning Outcomes:

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

- Relate the Maxwell's equation in differential and integral forms
- Interpret the behavior of plane electromagnetic waves in vacuum
- Summarize the significance of Maxwell's equations
- Evaluate the energy density of electromagnetic wave
- Describe the wave propagation in vacuum and medium

Pedagogy tools: Blended learning,Case let, video lectures, self-reading

UNIT - V Sensors 9 Hours

Sensors (qualitative description only); Different types of sensors and applications; Strain and pressure sensors -Piezoelectric, magnetostrictive sensors, ultrasonic sensors; Fibre optic methods of pressure sensing; Temperature sensor -bimetallic strip, pyroelectric detectors; Hall-effect sensor; Smoke and fire detectors

Learning Outcomes:

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

- Illustrate the principle of strain and pressure sensors

- explain the principle and working of magnetostrictive and piezoelectric sensors
- Evaluate the fibre optic methods of pressure sensing
- Infer the functioning of temperature sensors like bimetallic strip and pyroelectric detectors
- State the principle and working of Hall-effect sensor, smoke and fire detectors

Pedagogy tools: Blended learning,Case let, video lectures, self-reading

Textbook(s):

1. Mechanics, D.S. Mathur, S.Chand and Company Limited, 2000.
2. A Text Book of Optics, 25/e, Brij Lal, M N Avadhanulu & N Subrahmanyam, 2012, S. Chand Publishing.
3. Ian R Sinclair, Sensor and Transducers 3rd eds, 2001, Elsevier (Newnes)
4. David J. Griffiths, "Introduction to Electrodynamics"-4/e, Pearson Education,2014
5. M.N. Avadhanulu, P.G. Kshirsagar, A Textbook of Engineering Physics, S.Chand, 2014.

Reference Book(s):

1. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
2. Prithwiraj Purkait, Budhaditya Biswas and Chiranjib Koley, Chapter 11 Sensors and Transducers, Electrical and Electronics Measurements and Instrumentation, 1st eds., 2013 McGraw Hill Education (India) Private Limited.
3. Elements of Properties of Matter, D. S. Mathur, S. Chand Publishing

Journal(s):

1. https://aapt.scitation.org/doi/abs/10.1119/1.3317450
2. https://aapt.scitation.org/doi/full/10.1119/1.3639154

CHEM1001: CHEMISTRY

L	T	P	C
3	0	2	4

This course enables the students to gain knowledge on various aspects of Water and its treatment, electrochemical energy systems, Construction of batteries, renewable energy sources, Semiconductors, Steel, Cement and Polymers, Corrosion and its control, nano-materials, Analytical instruments and applications. The knowledge gained in this course can be applied to the latest developments in technology.

Course objectives

- To impart knowledge on various aspects of water and its treatment.
- To study about electrochemical energy systems, renewable energy sources, solar cells and their applications.
- To gain knowledge on materials such as steel, cement and polymers
- To create awareness on corrosion and its control.
- To introduce different types of nano-materials.
- To expose the students to latest instrumental techniques such as scanning electronic microscope (SEM) & transmission electron microscope (TEM).

Unit-1: Water and its treatment **9L**

Water and its treatment: Introduction – hardness of water – Causes of hardness - Types of hardness: temporary and permanent – expression and units of hardness. Estimation of hardness of water by complexometric method. Potable water and its specifications. Steps involved in treatment of water – Disinfection of water by chlorination and ozonization- industrial water treatment- Boiler feed water and its treatment -internal conditioning– Calgon and Phosphate conditioning. External treatment of water – Ion exchange process. Desalination of water – Reverse osmosis.

Learning outcomes:

After the completion of the Unit I, the student will be able to

- list the differences between temporary and permanent hardness of water. (L-1)
- explain the principles of reverse osmosis. (L-2)
- compare the quality of drinking water with BIS and WHO standards. (L-2)
- illustrate problems associated with hard water. (L-2)
- demonstrate the Industrial water treatment processes. (L-2)

Unit-2: Electrochemical Energy Systems **9L**

Battery Technology: Basic concepts, battery characteristics, classification of batteries, Important applications of batteries, Classical batteries-dry/Leclanche cell, Modern batteries-zinc air, Lead-acid storage battery, lithium cells- Lithium ion cell, Li MnO_2 cell. Fuel cells- Introduction - classification of fuel cells – hydrogen and oxygen fuel cell, propane and oxygen fuel cell- Merits of fuel cell. **Renewable energy sources – Types of renewable energy sources. Semiconductors:** Definition, types of semiconductors: doping- n type and p – type semiconductors and applications.**-** **Solar cells:** Introduction, harnessing solar energy, Photovoltaic cell, solar water heaters.

Learning outcomes:

After the completion of the Unit II, the student will be able to

- define electrode potential. (L-1)

- explain Nernst's equation. (L-2)
- illustrate difference between primary and secondary cells. (L-2)
- summarize the applications of solar energy. (L-2)
- construct different cells. (L-3)

Unit-3: Engineering materials and Polymer Chemistry 8L

Steel – Types of Steel, chemical composition – applications of alloy steels
Cement: Portland cement, constituents, Manufacture of Portland Cement, chemistry of setting and hardening of cement (hydration, hydrolysis, equations).
Polymer Chemistry: Concept of polymerization – Types of Polymerization, Chain growth polymerization – mechanisms of free radical and cationic polymerizations, Thermoplastic resins and Thermosetting resins: examples- Polyethylene, Styrene, Nylon 6,6 and Bakelite. and applications, Conducting polymers:– Examples – and applications.

Learning outcomes:

After the completion of the Unit IV, the student will be able to

- classify the types of steel. (L-2)
- illustrate the chemical reactions involved in the manufacturing of cement. (L-2)
- identify preparation and properties of polymers. (L-3)
- distinguish between thermoplastic and thermo setting resins. (L-4)

Unit-4: Corrosion and its control 8L

Corrosion and Its Prevention: Electrochemical theory of corrosion, Corrosion due to dissimilar metal cells (galvanic cells), Corrosion due to differential aeration cells, Uniform corrosion, pitting corrosion and stress corrosion cracking, Effect of pH, temperature and dissolved oxygen on corrosion rate. Corrosion prevention and control by cathodic protection- protective coatings-paints.

Learning outcomes:

After the completion of the Unit III, the student will be able to

- explain theories of corrosion. (L-2)
- classify different corrosion methods. (L-2)
- summarize the various factors affecting corrosion. (L-2)
- identify different organic coatings. (L-3)
- apply the principles of corrosion control. (L-3)

Unit-5: Nanomaterials and Analytical Instrumental Techniques 8L

Nanomaterials: Introduction to nanomaterial: nanoparticles, nanocluster, carbon nanotube (CNT) and nanowires. Chemical synthesis of nanomaterials: sol-gel method. Characterization: Principle and applications of scanning electron microscope (SEM) and transmission electron microscope (TEM)

Analytical Instrumental Techniques

Review of electromagnetic spectrum, Quantization of energy. Absorption of radiation: Beer-Lambert's law. Principle and applications of pH metry, potentiometry, conductometry, IR and UV-spectroscopy with examples.

Learning outcomes:

After the completion of the Unit V, the student will be able to

- classify nanomaterials. (L-2)

- explain the synthesis and characterization methods of nano materials. (L-2)
- describe the principles of different analytical techniques. (L-3)
- compare the principles of SEM and TEM. (L-4)

Course outcomes

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

- list the important purification methods of water. (L-1)
- illustrate the principles and applications of batteries, solar energy. (L-2)
- explain the importance of materials such as steel, cement and polymers
- identify different protective coatings. (L-3)
- analyze the importance of nano materials and the principles of SEM and TEM. (L-4)

Text Books:

1. P.C. Jain and M. Jain, Engineering Chemistry, 15/e, Dhanapat Rai & Sons, Delhi (2014).
2. B.K. Sharma, Engineering Chemistry, Krishna Prakashan, Meerut.
3. O G Palanna, Engineering Chemistry, Tata McGraw Hill Education Private Limited, (2009).

Reference Books:

1. Sashi chawla, A Textbook of Engineering Chemistry, Dhanapath Rai and sons, (2003)
2. B.S Murthy and P. Shankar, A Text Book of NanoScience and NanoTechnology, University Press (2013).
3. S.S. Dara, A Textbook of Engineering Chemistry, S.Chand & Co, (2010)
4. N.Krishna Murthy and Anuradha, A text book of Engineering Chemistry, Murthy Publications (2014).
5. K. Sesha Maheshwaramma and Mridula Chugh, Engineering Chemistry, Pearson India Edn services, (2016).

CHEMISTRY LABORATORY

The course enables the students to gain knowledge on various, instrumental methods of analysis, measurements of physical parameters, volumetric analysis, preparation of polymers, analysis of water, and chromatographic separation techniques.

Course objectives

- To familiarize the students with the basic concepts of Chemistry lab.
- To train the students on how to handle the instruments.
- To demonstrate the digital and instrumental methods of analysis.
- To expose the students in practical aspects of the theoretical concepts.

List of experiments

1. Determination of Mohr's salt by potentiometric method
2. Determination of strength of an acid by pH metric method
3. Determination of conductance by conductometric method
4. Determination of viscosity of a liquid
5. Determination of surface tension of a liquid
6. Determination of sulphuric acid in lead-acid storage cell
7. Determination of chromium (VI) in potassium dichromate

8. Determination of copper in a copper ore
9. Determination of Zinc by EDTA method.
10. Estimation of active chlorine content in Bleaching powder
11. Preparation of Phenol-Formaldehyde resin
12. Preparation of Urea-Formaldehyde resin
13. Thin layer chromatography
14. Preparation of TiO2/ZnO nano particles
15. SEM analysis of nano materials

Course Outcomes:

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

- explain the functioning of the instruments such as pH, Conductometric and Potentiometric methods. (L-2)
- identify different ores (Cr & Cu) and their usage in different fields (industry, software devices, electronic goods). (L-3)
- experiment with the physical parameter of organic compounds. (L-3)
- compare the viscosities of oils. (L-4)
- list the preparation of polymers and nano materials. (L-4)

Text Books

1. Mendham J, Denney RC, Barnes JD, Thosmas M and Sivasankar B Vogel's Quantitative Chemical Analysis 6/e, Pearson publishers (2000).

2. N.K Bhasin and Sudha Rani Laboratory Manual on Engineering Chemistry 3/e, Dhanpat Rai Publishing Company (2007).

MATH1001 - SINGLE VARIABLE CALCULUS

L	T	P	C
2	0	0	2

This course is designed to impart knowledge on differentiation and integration of function, emphasizing their inter-relationship and applications to engineering.

Course Objectives:

- To familiarize the students in the concepts the derivatives and its underlying concepts like limits and continuity.
- To explain the concept of derivative and calculation of extreme values of extreme values of various functions.
- To impart knowledge on integration for the computation of areas, arc lengths.
- To demonstrate various techniques of integrations.

Unit I: Limits and continuity of single and several variables (6 hours)

Limit of a Function and Limit Laws, The Precise Definition of a Limit, One-Sided Limits, Continuity (Without proofs). Functions of Several Variables, Limits and Continuity in Higher Dimensions (Without proofs)

Learning Outcomes:

At the end of this unit, the student will be able to

- define and calculate limits and one-sided limits of single variables
- define and calculate limits of several variables.
- define continuity and determine whether a function is continuous of single and several variables.

Unit II: Derivatives and applications (7 hours)

The Derivative as a Function, Differentiation Rules, The Chain Rule, Extreme Values of Functions on Closed Intervals, Monotonic Functions (Without proofs)

Learning Outcomes:

At the end of this unit, the student will be able to

- know the definition of derivative and how to use the most common rules of derivatives
- apply various rules to obtain the derivatives of different functions.
- find the extreme values of various functions.

Unit III: Integrals and applications (7 hours)

The Definite Integral, The Fundamental Theorem of Calculus, Indefinite Integrals and the Substitution Method, Definite Integral Substitutions and the Area between Curves, Arc Length (Without proofs)

Learning Outcomes:

At the end of this unit, the student will be able to

- know about anti-derivative and the Fundamental Theorem of Calculus and its applications
- apply concept of integration to evaluate geometric area and solve other applied problems
- apply substitution to compute definite integrals.

Unit IV: Techniques of integration (6 hours)

Using basic Integration Formulas, Integration by Parts, Trigonometric Integrals, Trigonometric Substitutions, Integration of Rational Functions by Partial Fractions (Without proofs)

Learning Outcomes:

At the end of this unit, the student will be able to

- evaluate integrals using integration by parts.
- evaluate indefinite and definite integrals using by the method of substitution.
- evaluate integrals of trigonometric and rational functions.

Textbook:

1. Joel Hass, Christopher Heil, Maurice D. Weir, Thomas' Calculus, Fourteenth edition, Pearson Addison Wesley (2018).

References:

1. Erwin Kreyszig, Advanced Engineering Mathematics,10/e, John Wiley & Sons, 2018.
2. B. S. Grewal, Higher Engineering Mathematics, 44/e, Khanna publishers, 2017.
3. James Stewart, "Calculus: Early Transcendentals", Cengage Learning, 7th Edition, New Delhi, 2015.
4. Hyghes-Hallett, Gleason, McCallum et al. Single Variable Calculus (6th Edn) John Wiley and Sons New York, 2013.

Course Outcomes:

At the end of the course, the student will be able to

- determine limit, one sided limit, continuity of single and several variable functions.
- solve problems in a range of mathematical applications using the derivative or the integral.
- apply the fundamental theorem of calculus.
- evaluate integrals using various techniques.

MATH1011- SEVERAL VARIABLE CALCULUS

L	T	P	C
2	0	0	2

This course is designed to impart knowledge on calculus of functions of more variables which are useful in modelling and analyzing physical phenomena involving continuous change of variables or parameters and have applications across all branches of engineering.

Course Objectives:

- To teach basic concepts of partial derivatives.
- To explain the evaluation of double integrals and its applications.
- To demonstrate the evaluation and applications of triple integrals.
- To acquaint the knowledge of line and surface integrals and applications.

Unit I: Partial derivatives and applications (7 hours)

Partial Derivatives of a Function of Two Variables and More Than Two Variables, Second-order Partial derivatives, The Chain Rule for Functions of Two and Three variables, Extreme Values and Saddle Points, Lagrange Multipliers, Taylor's Formula for Two Variables (Without proofs)

Learning Outcomes:

At the end of this unit, the student will be able to

- find partial derivatives of various functions
- apply chain rule for functions of two and three variables
- evaluate maxima and minima of functions

Unit II: Double integrals (6 hours)

Double and iterated Integrals over Rectangles, Double Integrals over General Regions, Area by Double Integration : Area of bounded region in a plane, Double Integrals in Polar Form. (Without proofs)

Learning Outcomes:

At the end of this unit, the student will be able to

- evaluate double integrals of functions of several variables in two dimensions in Cartesian and polar coordinates.
- calculate the areas bounded by a region using double integration techniques.

Unit III: Triple integrals (5 hours)

Triple Integrals in Rectangular Coordinates: Triple Integrals, Volume of a Region in Space, Finding limits of integration, Triple Integrals in Cylindrical and Spherical Coordinates. (Without proofs)

Learning Outcomes:

At the end of this unit, the student will be able to

- find limits of integration
- evaluate multiple integrals in Cartesian, cylindrical and spherical geometries.
- find volumes using triple integrals.

Unit IV: Integrals and Vector fields (8 hours)

Vector Fields and Line Integrals: Line Integrals of Vector Fields, Line Integrals with Respect to dx, dy, or dz, Work Done by a Force over a Curve in Space, Green's Theorem in the Plane: Tangential form, Using Green's Theorem to Evaluate the Line Integral and Verification, Surface Integrals: Surface Integrals of Vector Fields, Stokes' Theorem (Without proofs)

Learning Outcomes:
At the end of this unit, the student will be able to

- find the work done in moving a particle along the path over a force field.
- find the rate of flow of a fluid across a surface.
- apply Green's and Stokes' theorem in evaluation of line, surface and volume integrals.

Textbook:

1. Joel Hass, Christopher Heil, Maurice D. Weir, Thomas' Calculus, Fourteenth edition, Pearson Addison Wesley (2018).

References:

1. Erwin Kreyszig, Advanced Engineering Mathematics,10/e, John Wiley & Sons, 2018.
2. B. S. Grewal, Higher Engineering Mathematics, 44/e, Khanna publishers, 2017.
3. Hyghes-Hallett, Gleason, McCallum et al. Multivariable Variable Calculus (6th Edn) John Wiley and Sons New York, 2013.
4. James Stewart. Multivariate Calculus, Concepts and Contexts. (3rd Edn) Thomson/Brooks/Cole, Canada, 2005.

Course Outcomes:
At the end of the course, the student will be able to

- utilize functions of several variables in optimization.
- employ the tools of calculus for calculating the areas.
- calculate volumes using multiple integrals.
- determine the work done and rate of flow of a fluid using vector calculus

MATH 1021: TRANSFORM TECHNIQUES

L	T	P	C
2	0	0	2

Preamble

This course is designed to impact the knowledge on (Laplace, Fourier) transforms and applications of these transforms on differential equations.

Course Objectives:

- To introduce and explain the concepts of Laplace transforms and properties.
- To demonstrate the evaluation of Laplace transforms of special functions and additional properties.
- To impart knowledge on obtaining Fourier series
- To introduce and explain the concepts of Fourier transforms and properties.
- To explain the evaluation of Fourier transforms of various function and then applications to boundary value problem.
- To demonstrate and understand the transform techniques using available software

Unit-1: Laplace transforms (5 hrs)

Introduction, transforms of elementary functions, properties of Laplace transforms, Transforms of derivatives, transforms of Integrals, Multiplication by t^n, Division by t.

Learning Outcomes:

After completion of this unit student able to

- find Laplace transform of a function (L3).
- examine the properties of Laplace transforms(L4).
- determine Laplace transform of functions like transforms of Integrals, Multiplication by t^n, Division by t (L4).

Unit-2: Applications of Laplace transforms (5 hrs)

Evaluation of integrals by Laplace transforms, Inverse transforms, Solution of Differential equations.

Learning Outcomes:

After completion of this unit student able to

- find the inverse Laplace transform of a function(L3)
- Solve ordinary differential equations by using Laplace transformation technique(L3).

Unit-3: Fourier Series (6 hrs)

Introduction, Conditions for a Fourier expansion, Functions having points of discontinuity, Change of interval.

Learning Outcomes:

After completion of this unit student able to

- find the Fourier series of a given function (L3)

- find the Fourier series by changing the given interval (L3)

MATH1031: DIFFERENTIAL EQUATIONS

L	T	P	C
2	0	0	2

Preamble

This course is designed to impact the knowledge on ordinary, partial differential equations and their applications.

Course Objectives:

- To familiarize the students with the basic concepts of ordinary differential equations.
- To demonstrate the evaluation and applications of first order differential equations.
- To explain the evaluations of linear homogeneous and non-homogeneous differential equations.
- To familiarize the students with the basic concepts of partial differential equations.
- To explain the concepts of first order partial differential equations.
- To demonstrate the evaluation of differential equations using math software

Unit-1: First Order Ordinary Differential Equations (5 hrs)

Order and Degree of an Ordinary Differential Equation(ODE),ODE's of first order and first degree, Variable separable method, Linear Equations, Bernoulli's Equations.

Learning Outcomes:

- apply various methods to solve first order and first degree differential equations (L3).
- distinguish between linear and non linear differential equations (L4).
- solve linear differential equations (L3).

Unit-2: Linear Ordinary Differential Equations of High Order (6 hrs)

Definitions, Complete Solution, Operator D, Complimentary function, Inverse operator, Rules for finding particular integral (e^{ax}, sinbx/cosbx, x^m& $e^{ax}v(x)$)

Learning Outcomes:

- classify the solutions of linear differential equations of higher order (L3)
- identify the essential characteristics of linear differential equations with constant coefficients (L3)
- solve the linear differential equations with constant coefficients by appropriate methods (L3)

Unit-3: Applications of Linear Ordinary Differential Equations of Higher Order (5 hrs)

Method of Variation of Parameters, Simple Harmonic Motion, Oscillations of a Spring

Learning Outcomes:

- solve the linear differential equations with Method of Variation of Parameters (L3)

- Solve application problems such as Simple Harmonic Motion and Oscillations of a string using linear ordinary differential equations of higher order (L3).

Unit-4:Introduction to Partial Differential Equations (5 hrs)
Introduction, Formation of Partial Differential Equation(PDE), Solutions of a PDE, Equations solvable by direct integration, Linear equations of the first order.
Learning Outcomes:
- find the partial differential equation (L3).
- find the solution of a partial differential equation (L3).
- solve PDE by direct integration (L3)

Unit-5: Partial Differential Equations of Second Order (5 hrs)
Homogeneous linear equations with constant coefficients, Rules for finding the complementary function and particular integral,Working procedure to solve the equations.
Learning Outcomes:
- apply a range of techniques to find solutions of PDEs (L3)
- identify the basic properties of PDEs (L3)
- find the solutions of homogenous and non-homogenous linear partial differential equations (L3).

Text Books:
1. Simmons, G.F., Differential Equations with Applications and Historical Notes, Second Edition, McGraw-Hill, Inc., 1991.
2. B. S. Grewal, Higher Engineering Mathematics, 44/e, Khanna publishers, 2017.

References:
1. Shepley L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, 1984
2. Sneddon, *Elements of Partial Differential Equations*, McGraw-Hill, International Edition, 1967.
3. Erwin Kreyszig, Advanced Engineering Mathematics,10/e, John Wiley & Sons, 2018.

Course Outcomes:
- form and find the solution of an ordinary differential equation (L3).
- apply the concept of differential equations to solve real world problems (L3).
- evaluate linear homogeneous and non homogeneous differential equations (L4)
- form and find the solution of a partial differential equations of first order (L3).
- evaluate second order partial differential equations (L4).
- evaluate solution of differential equations using computational tool (L4)

MATH1041: DISCRETE MATHEMATICS

L	T	P	C
2	0	0	2

Preamble :

Discrete Mathematics introduces students to the mathematics of networks, social choice, and decision making . This course provides students with a hands-on exploration of the relevancy of mathematics in the real world. This course reflects the rigor taught in many entry-level mathematics courses.

Course Objectives:

- To introduce basics of mathematical logical operators and connectives
- To impart knowledge on normal forms and rules of inference.
- To impart knowledge on partially ordered and total ordered sets.
- To familiarize closed form solution of linear recurrence relations by various methods.
- To impart knowledge on basic concepts of algebraic structures.
- To write program structures, and understand when programming is most applicable

Unit-1: Logic Operators and Connectives (5 hrs)

Negation, conjunction, disjunction, conditional and bi-conditional, well formed formulae, tautologies, equivalence of formulae, duality, tautological implications.

Learning outcomes:

After completion of this unit, student will be able to

- construct the truth table for given expressions (L3)
- identify tautologies, Contradiction or at least satisfiable and solve the decision problem. (L3)
- find equivalence formulas (L3)

Unit-2: Mathematical logic (5 hrs)

Conjunctive and disjunctive normal forms- principal disjunctive and conjunctive normal forms, Rules of inference for propositional calculus (Rule P, Rule T and CP rule).

Learning Outcomes:

After completion of this unit, student will be able to

- implement logic for mathematical proofs (L4)
- apply inference theory to verify the consistence of data (L3)

Unit-3: Sets and Relations (5 hrs)

Basic concepts of set theory, Power set, relations, properties of binary relations in a set, Equivalence relations, composition of binary relations, Partial ordering, Partially ordered set.Hasse diagram.

Learning Outcomes:

After completion of this unit, student will be able to

- identify different types of sets and relations (L3)
- test the given set is an equivalence relation or not (L4)

Unit-4: Recurrence relations **(5hrs)**

Recurrence relations, solving linear recurrence relations by characteristic roots method, system of recurrence relations.

Learning Outcomes:

After completion of this unit, student will be able to

- construct recurrence relations of the sequences (L3)
- solve homogeneous linear recurrence relations (L3)
- solve complementary function and particular integral for non-homogeneous linear recurrence relations (L3)

Unit-5: Algebraic Structures **(6 hrs)**

Algebraic Structures-Semi group, Monoid ,Groups, subgroups, cosets((definition and examples) Lagrange's theorem on finite groups

Learning Outcomes:

After completion of this unit, student will be able to

- test the given algebraic structure is a group or not (L3)
- identify different types of groups (L2)
- understand the significance and applications of Lagrange's theorem (L3)

Text Books:

1. J.P. Tremblay and R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, Tata McGraw Hill, 1997.
2. Kenneth H. Rosen, Discrete Mathematics and Applications, Seventh edition, Tata McGrawHill,2012.

Reference books:

1. Bhishma Rao, Mathematical Foundations of Computer Science, SciTech Publications (India) Pvt Ltd.
2. Discrete Mathematical Structures,Sixth edition-Kolman,Busby,Ross

Course Outcomes:

Upon successful completion of this course the student should be able to

- Check the validity of a statement formula (L2)
- analyze the concepts in set theory and relations (L3)
- find a general solution of recurrence equation (L3)
- build the algebraic structures (L3)
- Apply Lagrange's theorem on finite groups (L3)
- Convert problem solving strategies to procedural algorithms (L3)

MATH1051: GRAPH THEORY

L	T	P	C
2	0	0	2

Preamble
This course introduces basic concepts in Graph Theory, including properties and characterization of graph/trees and graph theoretic algorithms, which are widely used in Mathematical modelling and has got applications across Computer Science and other branches in Engineering.

Course Objectives:
- To introduce basics of group theory and its applications
- To impart knowledge on basic concepts of paths and circuits
- To impart knowledge on Trees, spanning trees, shortest spanning trees
- To familiarize in the matrix representation of graphs
- To transform scientific problems into generic computational models

Unit-1: Basics of graphs (5 hrs)
Finite and Infinite Graphs, Incidence and Degree, Isolated Vertex, Pendant Vertex, and Null Graph, complete graph, Bi-partite and complete Bi-partite graphs.
Learning Outcomes:
After completion of this unit, student will be able to
- understand the basic terminology of the graph theory (L2).
- find the vertex of the graph and identify the types of vertices of the graph(L3).

Unit-2: Matrix representation of graphs: (5hrs)
Adjacency Matrix, Incidence Matrix, Path Matrix(Definition and examples),
Learning Outcomes:
After completion of this unit, student will be able to
- identify the types of matrix representation of graph (L3)
- Find a path matrix of a connected graph (L3)

Unit-3: Paths and circuits (6 hrs)
Paths, and Circuits, Connected Graphs, Disconnected Graphs, and Components, Euler Graphs,Hamiltonian graphs(Definition,examples and without proofs)
Learning Outcomes:
After completion of this unit, student will be able to
- identify different types of paths and their properties (L3)
- construct Euler and Hamiltonian graphs (L3)

Unit-4: Trees (5 hrs)
Trees and their properties, spanning trees, minimal spanning trees,
Kruskal’s algorithm for finding a minimal spanning tree,
Learning Outcomes:
After completion of this unit, student will be able to

- construct the spanning trees from graphs (L3)
- build minimal spanning tree by Kruskal’s algorithms (L3)

Unit 5: Applications of Trees and Fundamental circuits (5 hrs)

Preorder, in order and post order traversals, Prefix and Postfix notations of an arithmetic expression, parsing trees.

Learning Outcomes:

After completion of this unit, student will be able to

- Identify tree traversals (L3)
- construct parsing trees for algebraic expressions (L3)

Text Book:

1. J.P. Tremblay and R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, Tata McGraw Hill, 1997.
2. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall of India, 2006.

Reference Book:

1. Bhishma Rao, Mathematical Foundations of Computer Science, SciTech Publications (India) Pvt Ltd.
2. Kenneth H. Rosen, Discrete Mathematics and Applications, Seventh edition, Tata McGrawHill,2012.

Course Outcomes:

Upon successful completion of this course the student should be able to

- analyse the concepts in graph theory (L4)
- apply graph theory concepts in core subjects such as data structures and network theory effectively (L3)
- Identify different types of paths (L3)
- Construct minimum spanning tree using some algorithms (L3)
- Identify tree traversals (L3)
- Solve the graphical problems which are accessed in available software (L3)

MATH1061 - INTRODUCTION TO MATHEMATICS I

L	T	P	C
2	**0**	**0**	**2**

This course is designed to provide an introduction to the mathematics required for basic physics, engineering mathematics, and introductory engineering courses.

Course Objectives:

- To explain the concepts of Trigonometry.
- To explain the basic concepts of differentiation and differential equations
- To teach the evaluation of definite and indefinite integrals.

Unit- I : **3 hrs**

Representations for Scalars, Vectors, Matrices and Tensors.
Coordinate systems: cartesian and polar coordinate systems.

Learning Outcomes:

At the end of this unit, the student will be able to

- Describe representational forms (L1)
- Understand the basis of coordinate systems (L1)

3 hrs

Unit- II : Trigonometry

Trigonometric functions, periodicity, trigonometric ratio of compound angles, multiple and sub multiple angles, transformations, brief introduction of inverse trigonometric, hyperbolic and inverse hyperbolic functions.

Learning Outcomes:

At the end of this unit, the student will be able to

- identify trigonometric functions and their properties (L3)
- apply the trigonometric ratio techniques of compound angles, multiple and sub multiple angles in calculations (L3)
- find inverse trigonometric and hyperbolic functions (L3)

8 hrs

Unit- III : Differential Calculus

Limits and Continuity: Definition of right hand limit, left hand limit, standard limits

1) $\lim\limits_{x \to a} \frac{x^n - a^n}{x - a}$ 2) $\lim\limits_{\theta \to 0} \frac{\sin\theta}{\theta}$ 3) $\lim\limits_{n \to 0} \left(1+n\right)^{\frac{1}{n}}$ 4) $\lim\limits_{x \to 0} \frac{e^x - 1}{x}$

5) $\lim\limits_{x \to 0} \frac{a^x - 1}{x}$

(without proofs)**,** definition of continuity and simple illustrations.

Differentiation: Introduction, definition, differentiation of a function at a point and on an interval, derivative of a function, differentiation of sum, difference, product and quotient of functions, differentiation of algebraic, exponential, logarithmic functions, composite, implicit, parametric, hyperbolic, inverse hyperbolic functions, logarithmic differentiation, derivatives of first and second order.

Learning Outcomes:

After completing this unit, the student will be able to

- find derivative of sum, difference, product and quotient of functions (L3)
- apply differentiation techniques in different forms of functions (L3)
- calculate the derivatives of simple functions (L4)

8 hrs

Unit IV: Integration

Indefinite Integrals: Integration as the inverse process of differentiation, standard forms, properties of integrals, integration by the method of substitution covering algebraic, trigonometric, exponential functions, integration by parts, logarithmic functions, inverse trigonometric functions.

Definite Integrals: Definition of a definite integral and its properties (without proof), formulae

Of $\int_0^{\pi/2} Sin^n\theta\, d\theta$, $\int_0^{\pi/2} \cos^n\theta\, d\theta$ and $\int_0^{\pi/2} \cos^n\theta\, Sin^m\theta\, d\theta$ (without proofs).

Learning Outcomes:

After completing this unit, the student will be able to

- find integrals of special functions (L3)
- apply partial fractions technique on evaluation of integrals of rational functions (L3)
- solve definite integrals in trigonometric functions (L3)
    - solve simple integrals (L3)
    - apply substitution and by parts techniques in evaluation of integrals (L3)
    - find logarithmic, inverse trigonometric functions (L3)

10 hrs

Unit V: Introduction to differential equations and Multivariable calculus

Linear first order differential equations with constant coefficients, linear second order differential equations with constant coefficients (Definitions only). Only basic concepts of Partial differentiation. Only basic concepts of Differential forms: gradient, divergence and curl. Introduction to line, surface and volume integrals (without problems) illustrated with Stokes, Gauss, and Green's theorems (Only statements).

Learning Outcomes:

- solve problems involving trigonometric functions (L3)
- understand the principles of differential and integral calculus (L3)
- solve first order linear differential equations with constant coefficients (L3)
- solve first order linear differential equations with constant coefficients (L3)
- understand the basic concepts of vector calculus (L1)

Course Outcomes:

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

- solve problems involving trigonometric functions (L3)
- understand the principles of differential and integral calculus (L3)
- solve first order linear differential equations with constant coefficients (L3)
- solve first order linear differential equations with constant coefficients (L3)
- understand the basic concepts of vector calculus (L1)

Text Books:

1. Text book for Intermediate Mathematics, Board of Intermediate Education, AP, Volumes IA, IB & IIA, 2018.
2. NCERT class XI and XII (part 1) Mathematics text books.

References:

1. V. Venkateswara Rao, N. Krishna Murthy, B.V.S. Sharma, Intermediate Mathematics, S.Chand & Company Ltd., Volume I & II.
2. Chandrika Prasad, A first Course in Mathematics.
3. Text book for Intermediate Mathematics, Deepti Publications.

MATH1071 - INTRODUCTION TO MATHEMATICS II

L	T	P	C
2	**0**	**0**	**2**

This course is designed to provide an introduction to the mathematics required for basic physics, engineering mathematics, and introductory engineering courses.

Course Objectives:

- To describe the basic concepts of matrices
- To introduce complex numbers and their properties.
- To teach the technqiues based on partial fractions
- To explain the concepts of straight lines and circles

Unit I: Matrices **8hr**

Matrices, determinants, definition, types of matrices, algebra of matrices, properties of determinants of 2 X 2, 3 X 3 matrices, inverse of a matrix, solving simultaneous linear equations in two and three variables using matrix inverse method, Cramer’s rule and Gauss Jordan method. Eigenvalues and Eigenvector of matrices.

Learning Outcomes:

At the end of this unit, the student will be able to

- find determinants of matrices (L3)
- apply crammer‟s rule for solving linear equations (L3)
- find inverse of a matrix (L3)

Unit- II : Complex Numbers **6 hrs**

Complex number as an ordered pair of real numbers, representation of $z = (a, b)$ in the form $(a + ib)$ conjugate complex numbers, modulus and amplitude of a complex number, geometrical representation of a complex number, Argand diagram.

Learning Outcomes:

- solve arithmetic problems involving complex numbers (L3)
- find the conjugate, modulus and amplitude of a complex number (L3)
- describe the relationship between a complex number and Argand plane (L3)

Unit III: Partial Fractions **6 hrs**

Introduction, resolving $g(x)$ into partial fractions when $g(x)$ contains non repeated linear factors, repeated linear factors, repeated and non-repeated irreducible quadratic factors.

Learning Outcomes:

After completing this unit, the student will be able to

- find a fractional function and resolve it into partial fractions (L3)
- make use of resolving techniques of repeated and non repeated linear factors (L3)
- apply this technique in evaluation of integrals (L3)

Unit IV: Co-ordinate Geometry **14 hrs**

Straight lines: Recapitulation of general equation of a straight line, forms of equation of a straight line: slope intercept form, intercept form, point -slope form, two point form, normal form $x\cos\alpha + y\sin\alpha = p$, point of intersection of two straight lines, line passing through the point of intersection of two given lines, condition for concurrency of three straight lines, angle between two intersecting lines, condition for perpendicularity and parallelism, length of the perpendicular from a point to a straight line, distance between two parallel lines (without proofs).

Circles: Equation of a circle, standard form, centre and radius, equation of a circle with a given line segment as diameter, equation of a circle through three non collinear points, parametric equations of a circle, position of a straight line in the plane of the circle.

3D Geometry: Equation of a plane, Intersection of two planes, Equation of a sphere in spherical and cartesian coordinates, Intersection of a plane and a sphere.

Learning Outcomes:

After completing this unit, the student will be able to

- identify the equation to straight line in different forms(L3)
- find the length of permutation from a point to a straight line(L3)
- find the equation of a circle passing through three non collinear points(L3)

Course Outcomes:

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

- describe the properties of matrices (L3)
- describe the properties of complex numbers (L3)
- illustrate straight line and circle properties(L3)

Text Books:

1. Text book for Intermediate Mathematics, Board of Intermediate Education, AP, Volumes IB, IIA & IIB, 2018.
2. NCERT class XI and XII (part 1 & 2) Mathematics text books.

References:

1. V. Venkateswara Rao, N. Krishna Murthy, B.V.S. Sharma, Intermediate Mathematics, S. Chand & Company Ltd., Volume I & II.
2. Chandrika Prasad, A first Course in Mathematics.
3. Text book for Intermediate Mathematics, Deepti Publications.

DIFFERENCE EQUATIONS

L T P C
2 0 0 2

Preamble: Difference equations is the study of equation which involves the difference of a discrete function. In this course, the student can form a difference equation, solving linear higher order difference equations using analytical techniques, simultaneous linear difference equations and also find the solution of linear higher order difference equations and simultaneous difference equations using Z-transforms.

Course Objectives:

1. Student is able to know how to find the order of a difference equation and complementary function of a difference equation.
2. Student is able to know how to find the particular solution of a difference equation and also find the solutions of simultaneous linear difference equations.
3. Student is able to know how to find Z-transforms a discrete function using properties and using to basic theorems.
4. Student is able to know how to find the inverse Z-transforms a function and also using convolution theorem.
5. Student is able to know how to find the solution of a difference equation using Z-transforms

UNIT-I: (Difference equations-I) (5 hrs)

Introduction, definition of order, and solution of difference equation, formation of difference equations, linear difference equations, complementary function, rule for finding complementary function.

Learning outcomes:

- Student will be able to know how to find the order of a difference equation and complementary function of a difference equation.

UNIT-II: (Difference equations-II) (5 hrs)

Particular integrals, Rule for finding particular integrals, simultaneous linear difference equations.

Learning outcomes:

- Student will be able to know how to find the particular solution of a difference equation and also find the solutions of simultaneous linear difference equations.

UNIT-III: (Z-transforms) (5 hrs)

Introduction, Definition, some standard Z-transforms, linear property, damping rule, Shifting U_n to the **right and to the left, Multiplication by n, two basic theorems.**

Learning outcomes:

Student will be able to know how to find Z-transforms a discrete function using properties and using to basic theorems.

UNIT-IV: (Inverse Z-transforms) (5 hrs)

Convergence of Z-transforms, evaluation of inverse Z-transforms, properties, convolution theorem.

Learning outcomes:

Student will be to know how to find the inverse Z-transforms a function and also using convolution theorem.

UNIT-V: (Applications of Z-transforms) (5 hrs)
Solving difference equations and simultaneous linear difference equations with constant coefficients by Z-transforms.
Learning outcomes:
Student will be able to know how to find the solution of a difference equation using Z-transforms.

Text Book:
1. "Higher Engineering Mathematics" by B.S. Grewal published by Khanna Publishers

Reference books:
1. Advanced Engineering mathematics by Irvin Kreyszig

Course Outcomes:
1. Able to find the order of a difference equation and complementary function of a difference equation.
2. Able to find the particular solution of a difference equation and also find the solutions of simultaneous linear difference equations.
3. Able to find Z-transforms a discrete function using properties and using to basic theorems.
4. Able to find the inverse Z-transforms a function and also using convolution theorem.
5. Able to find the solution of a difference equation using Z-transforms

NUMERICAL TECHNIQUES

L	T	P	C
2	0	0	2

Preamble
This course is designed to enhance problem solving skills of engineering students using a powerful problem-solving tool namely numerical Techniques. The tool is capable of handling large systems of equations, nonlinearities and complicated geometries that are common in engineering practice but often impossible to solve analytically.

Course Objectives:

- To familiarize the students with numerical solutions of nonlinear and systems of linear equations.
- To get exposed to finite differences and interpolation.
- To demonstrate the numerical differentiation and integration.
- To explain the numerical solutions of ordinary differential equations

Unit-1: **(6 hours)**
Solution of algebraic and transcendental equations: Regula-falsi method and Newton-Raphson method. **Solution of linear system of equations-**Iterative methods: Gauss Jacobi method, Gauss Seidel method, and finding the eigenvalues of a matrix by Power method.
Learning Outcomes:
At the end of this unit, the student will be able to

- find approximate roots of an equation by using different numerical methods (L3).
- solve system of linear equations using various techniques (L3).
- find eigenvalues of a matrix (L3).

Unit-2: **(5 hours)**
Interpolation: Difference operators (shifting, delta, del) and difference tables, Newton's forward and backward interpolation formulae, Divided difference formula, and Lagrange's interpolation formula.
Learning Outcomes:
At the end of this unit, the student will be able to

- find a function using various methods (L3).

Unit-3: **(5 hours)**
Numerical Differentiation: Derivatives using forward, and backward difference formulae.
Numerical Integration: Trapezoidal rule, Simpson's 1/3rd rule, Simpson's 3/8th rule.
Learning Outcomes:
At the end of this unit, the student will be able to

- find differentiation of a function by using different numerical methods (L3)
- find integration of a function by using different numerical methods (L3)

Unit-4: **(5 hours)**

Numerical solutions of ordinary differential equations-1: Picard’s method, Taylor’s series method, Euler’s method, and Modified Euler’s method.

Learning Outcomes:

At the end of this unit, the student will be able to

- solve first order differential equation using various methods (L3).

Unit-5: **(5 hours)**

Numerical solutions of ordinary differential equations-2: Runge-Kutta method (second and fourth order), Predictor-Corrector methods-Adams-Bashforth and Milne’s methods.

Learning Outcomes:

At the end of this unit, the student will be able to

- solve first order differential equation using predictor-corrector methods (L3).

Text Book(s):

1. B. S. Grewal, Higher Engineering Mathematics, 44/e, Khanna Publishers, 2017.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 10/e, John Wiley & Sons, 2018.

References:

1. M.K. Jain, S.R.K. Iyengar, R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 5/e, New Age International(P) Limited, 2007.
2. S.S. Sastry, Introductory methods of Numerical Analysis,4/e,PHI Learning Publications,2009.
3. H.C Saxena, Finite Differences and Numerical Analysis, Chand and Company Pvt. Ltd., New Delhi.

Course Outcomes:

At the end of the course, the student will be able to

- analyze how root finding techniques can be used to solve practical engineering problems (L4).
- apply various interpolation techniques to solve practical problems (L3).
- apply numerical differentiation and integration whenever and wherever routine methods are not applicable (L3).
- solve differential equations using various numerical methods (L3).
- know the strengths and weaknesses of the various methods and be able to decide which ones are appropriate for a particular problem (L3)

OPERATIONS RESEARCH

L	T	P	C
2	0	0	2

Preamble:

Operations Research (OR), also known as management science, has become an indispensable tool in scientific management. Operations Research focuses on developing and analyzing strategic and tactical levels to aid in decision-making and decision-making on the operational level. The essential tools of OR are algorithms, procedures that create and improve solutions to a point at which optimal or, at least, satisfactory solutions have been found.

Course Objectives: This course is designed to:

- introduce the fundamentals of Operations Research to the students at the undergraduate level
- solve different types of optimization problems of various categories and applying modern methodologies in the area of optimization
- help students to develop a deep understanding of the classical and numerical optimization techniques and problem-solving capabilities

Unit – I **4 hours**

Linear Programming: Formulation of LPP, convex sets and their properties, slack and surplus variables, Basic solution, Basic feasible solution, non-degenerate and degenerate basic feasible solutions, optimal solution, General, Standard, and Canonical form of LPP.

Learning Outcomes :

After completion of this unit, the student will be able to:

- understand the problem of linear programming problem (L2)
- understand the definitions of Basic solution(BS), Basic Feasible Solution(BFS), Non-degenerate BFS, Degenerate BFS, and optimal solution of LPP (L2)
- know convex sets and some essential theoretical concepts about convex sets (L2)
- writing standard and canonical forms of LPP (L3)

Unit – II **8 hours**

Simplex Method: Simplex method, Degeneracy in LPP, Artificial variables techniques-Two Phase method, Big M-method.

Learning Outcomes:

After completion of this unit, the student will be able to:

- prepare simplex table (L4)
- apply the simplex algorithm for finding the optimal solution of given LPP (L2)
- know the cases of existence of degeneracy in LPP (L4)
- solving LPP by artificial variable techniques like II-phase and Big M-methods (L3)

Unit – III **5 hours**

Duality: Duality in linear programming, primal-dual relationships, weak duality theorem, strong duality theorem, and dual simplex method.

Learning Outcomes:

After completion of this unit, the student will be able to:

- find the relation between primal and dual problems (L3)
- know the advantage of writing the dual problem (L4)
- apply dual simplex method (L2)
- know the properties of duality (L4)

Unit – IV **4 hours**

Integer Programming: Gomory's cutting plane method, Branch and Bound method for solving integer linear programming problems.

Learning Outcomes :

After completion of this unit, the student will be able to:

- understand the problem of Integer programming problem (L2)
- apply the technique of cutting plane methods (L2)
- apply Gomory's cutting plane method to solve ILPP (L2)
- apply branch and bound method to solve ILPP (L2)

Unit – V **5 hours**

Sensitivity Analysis: Introduction to sensitivity analysis, variations in the price vector, variations in the requirement vector, addition of a new decision variable to the existing problem.

Learning Outcomes :

After completion of this unit, the student will be able to:

- understand the meaning of sensitivity analysis (L2)
- apply sensitivity analysis to find variations in price vector (L2)
- find variations in requirement vector (L3)
- find the extent to which an additional decision variable can be introduced to the problem (L3)

Course outcomes:

On successful completion of this course, students will be able to:

- understand the linear programming problem, its formation, and basic definitions of solutions
- understand the simplex method, which is a very efficient algorithm to solve a linear programming problem
- understand the dual primal relationship, properties of duality, and the dual simplex algorithm
- find integer solutions to LPP by cutting plane methods
- find variations in price and requirement vectors and retaining optimality

Text Books:

1. Operations Research by S.D.Sarma, Kedarnath, Ramnath and company, 15th edition, 2008.
2. Operations Research An Introduction by Hamdy A. Taha, 8th edition, Pearson, 2007.

Reference Books:

1. Linear Programming by R K Gupta, Krishna Prakashan Mandir, 13th edition 2014.
2. Operations Research Theory and Applications by J K Sharma, 4th edition, Macmillan Publishers India Ltd, 2009.

COMPLEX VARIABLES

L T P C
2 0 0 2

Preamble

This course is designed to familiarize the students with complex analysis, nature of a series, evaluation of integrals using Cauchy's theorem.

Course Objectives

- To explain the concept of complex functions and analytic functions.
- To explain the concept of conformal mapping.
- To explain the concept of Cauchy's theorem and residue theorem.
- To explain the convergence of series such as Taylor's and Laurent.
- To explain the concept of Cauchy's theorem and residue theorem.

MODULE – I **6 hours**

Functions of a Complex variable: Limit and continuity, Differentiation, Analytic functions, Cauchy-Riemann equations, harmonic functions, finding harmonic conjugates- applications to flow problems.

After completion of this unit student able to

- Identify continuous and differentiable complex functions (L3)
- apply Cauchy-Riemann equations to complex functions in order to determine whether a given continuous function is analytic (L3)
- give an account of the concepts of analytic function and harmonic function and to explain the role of the Cauchy-Riemann equations(L3).

Module - II **5 hours**

Geometrical representation of f(z) – Some standard transformations – Bilinear transformation - Conformal mappings. Special conformal transformations ($w = z^2$, $w= z+1/z$, $w = e^z$, $w= \cosh z$) .

Learning Outcomes:

After completion of this unit student able to

- To know the geometrical representation of an analytical functions(L2)
- explain the concept of conformal mapping, describe its relation to analytic functions, and know the mapping properties of the elementary functions(L3)

MODULE – III **5 hours**

Complex Integration: Integration of complex functions - Cauchy's theorem - Cauchy's integral formula.

Learning Outcomes:

After completion of this unit student able to

- define and evaluate complex contour integrals(L3);
- give an account of and use the Cauchy integral theorem, the Cauchy integral formula and some of their consequences(L3);

MODULE – IV **5 hours**

Series representation of analytic functions
convergent series of analytic functions, Laurent ‘s and Taylor series, zeros and singularities of an analytic function

Learning Outcomes:
After completion of this unit student able to

- analyze simple sequences and series of functions with respect to uniform convergence, describe the convergence properties of a power series, and determine the Taylor series or the Laurent series of an analytic function in a given region (L3);
- Determining the nature of the singularities and calculating residues (L2)

MODULE – V **5 hours**
Calculus of residues – Residue- Cauchy Residue theorem – Calculation of residues (All theorems without proof).

Learning Outcomes:
After completion of this unit student able to

- make use of the Cauchy residue theorem to evaluate certain integrals (L3)

Text Book:

1. B.S.Grewal, Higher Engineering Mathematics, 42nd Edition, Khanna Publishers, New Delhi, 2012.

Reference Books:

1. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics Narosa Publishing House, New Delhi, 2014.
2. N. P. Bali and Manish Goyal, A Text Book of Engineering Mathematics, 8th Edition, Lakshmi Publications, New Delhi, 2012.

Course Outcomes

1. Make use of differentiation and integration of complex functions in engineering problems (L3)
2. Concept of conformal mappings (L3).
3. Use Cauchy’s theorem and Cauchy’s integral formula to evaluate the line integrals (L3)
4. Apply Taylor’s and Laurent’s series to expand complex functions and know about the convergence region (L3).
5. Evaluation of integrals using Residue theorem(L3).

NUMBER THEORY

L	T	P	C
2	0	0	2

PREAMBLE

This course is designed to explain the basics and applications of number theory for the students of Computer Science. The core courses of these branches encounter with concepts like prime factorization, modular arithmetic, and quadratic reciprocities in number theory. The first unit of the course provide a strong platform for such encounters and the other units focuses on applications of number theory.

Course Objectives

- To teach basic concepts of number theory focusing on Computational aspects.
- To teach the concepts of factorization of integers.
- To teach Format's theorem and quadratic residues.
- To explain Chines remainder theorem and Euclidean algorithm.
- To explain polynomial arithmetic.

Unit 1 **(5 hrs)**

Basic Concepts in Number Theory: Topics in elementary number theory, Divisibility, Greatest Common Divisor

Learning Outcomes:

After completion of this unit, student will be able to

- develop the basics of number theory: (L3)
- perceive the concept of divisibility: (L5)

Unit 2 **(5 hrs)**

Euclidean Algorithm, Factorization of integers, Congruence, Modular arithmetic**,** some applications to factorizing, finite fields

Learning Outcomes: After completion of this unit, student will be able to

- understand the basics modular arithmetic: (L3)
- know some concepts on factorization: (L5)

Unit 3 **(5 hrs)**

Quadratic residues, Fermat's theorem, Euler ϕ function, Cauchy 's theorem

Learning Outcomes:

After completion of this unit, student will be able to

- learn some theorems on number theory: (L3)
- perceive the concept of quadratic residues (L5)

Unit 4 **(5 hrs)**

Chinese Remainder theorem, Primality testing algorithm, Euclid's algorithm for integers

Learning Outcomes:

After completion of this unit, student will be able to

- learn some theorems on number theory: (L3)
- apply primality testing algorithm (L5)

Unit 5 **(5 hrs)**

Polynomial Arithmetic, Primitive roots, Legendre symbol, Jacobi symbol

Learning Outcomes:

After completion of this unit, student will be able to

- learn polynomial arithmetic: (L3)
- perceive the Legendre and Jacobi symbols (L5)

Text Book

1. Elementary Number Theory | 7th Edition by David Burton, Mc Graw Hill Education

References

1. Basic Number Theory by S.B. Malik,S. Chand publishers

LINEAR ALGEBRA

L	T	P	C
2	0	0	2

Preamble

This course is designed to gain knowledge in the concepts of Linear Algebra focusing on basics of matrices, vector spaces and singular value decomposition to understand the basic concepts of Linear Algebra in the applications of image processing and machine learning.

Course Objectives:

- To familiarize with theory of matrices and tools for solving system of linear equations
- To impart knowledge on Eigen values and Eigen vectors.
- To teach basic concepts of vector spaces and their properties.
- To explain the concepts of inner product spaces.
- To familiarize with concept of singular value decomposition and its applications.

Unit-1: Fundamentals of Matrices: (5 hours)

Introduction to Matrices and Rank of a matrix, Echelon form, solving system of linear equations.

Learning Outcomes:

At the end of this unit, the student will be able to

- Reduce given matrices to Echelon form, (L3)
- solve the system of linear equations (L3)

Unit-2: Eigen values and Eigen vectors: (5 hours)

Eigen values and Eigen vectors, positive definite matrices, Linear dependence and Linear independence.

Learning Outcomes:

At the end of this unit, the student will be able to

- calculate Eigen values and Eigen vectors(L4)
- examine the definiteness of the matrix (L3)

Unit-3: Vector Spaces: **(6 hours)**

Vector space, linear combination of vectors, linear span, basis and dimension, linear Transformation.

Learning Outcomes:

At the end of this unit, the student will be able to

- examine whether a set of vectors form a basis(L3)
- analyze properties of a linear transformations(L4)

Unit-4: Inner Product Spaces (5 hours)

Inner Product Spaces, examples of inner product spaces, norm and length of a vector cauchy-schwarz's inequality.

Learning Outcomes:

At the end of this unit, the student will be able to

- understand an inner product(L3)
- apply Cauchy-Schwartz's inequality(L3)

Unit-V: **Singular value decomposition** **(5 hours)**

Singular values, computing singular value decomposition and Introduction to principal component analysis.

Learning Outcomes:

At the end of this unit, the student will be able to

- singular value decomposition and computing. (L4)
- understand singular value decomposition and principal Component analysis(L5).

Text Books:

1. Higher Engineering Mathematics, B. S. Grewal.
2. Linear Algebra, Schaum's Outline,4th edition, Seymour Lipchutz,Marc Lipson

Reference Books:

1. Advanced Engineering Mathematics, 7th Edition, Peter V. O'Neil.
2. Advanced Engineering Mathematics, 2nd Edition, Michael. D. Greenberg.
3. Introduction to linear algebra, 5th Edition, Gilbert Strang.
4. Applied Mathematics (Vol. I & II) , by P. N. Wartikar& J. N. Wartikar.
5. Digital Image Processing, R C Gonzalez and R E Woods.

Course Outcomes:

At the end of the course the student will be able to

- solve the system of linear equations (L3)
- calculate Eigen values and Eigen vectors(L4)
- Finding the basis(L4)
- learn Singular value decomposition and principal Component analysis (L5)

PROBABILITY THEORY AND RANDOM VARIABLES

L	T	P	C
2	0	0	2

Preamble

To expose the students to the basics of probability theory and random processes essential for their subsequent study of analog and digital communication.

Course Objectives:

- To know about various random life length models and their uses in finding the reliability of different electronic devices.
- To learn about basic properties and characteristics of various random processes with reference to signal and trunk processes.

Unit 1: Probability **5 hours**

Axioms of probability theory. Probability spaces. Joint and conditional probabilities. Bayes' Theorem- Independent events.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand events and how to assign probabilities to outcomes (L3)
- Solve applications involving probabilities (L4)

Unit 2: Random Variable **5 hours**

Random variables and random vectors. Distributions and densities. Independent random variables. Functions of one and two random variables.

Learning Outcomes:

At the end of this unit, the student will be able to

- evaluate moments and cumulative distribution functions for both discrete and continuous random variables (L3)
- characterize functions of random variables (L5)

Unit 3: Multiple Random Variables **6 hours**

Vector random variables, joint distribution and density functions, properties, conditional distribution and density, statistical independence, distribution and density of a sum of random variables, central limit theorem.

Learning Outcomes:

At the end of this unit, the student will be able to

- describe conditional and independent events and conditional random variables (L3)
- describe independent events and independent random variables and their sums (L3)

Unit 4: Expected Value of a Function of Random Variables **6 hours**

Joint moments about the origin, joint central moments, jointly Gaussian random variables - two random variables case, N random variable case.

Learning Outcomes:

At the end of this unit, the student will be able to

- characterize jointly multiple discrete and continuous random variables (L5)

- describe N Random variables independent events and independent random variables and their sums (L3)
- characterize jointly multiple discrete and continuous random variables (L5)

Unit 5: Random Process **6 hours**

Temporal characteristics - the random process concept, stationarity and statistical independence, correlation functions, Gaussian random processes, Poisson random process.

Learning Outcomes:

At the end of this unit, the student will be able to

- explain basic concepts of a random process, calculate the mean, variance, autocorrelation, and power spectral density of a stationary random process (L3)
- apply the knowledge of random variables in real life situations (L5)

Text Book(s)

1. Peyton Z. Peebles, Probability, Random Variables and Random Signal Principles, 4/e, Tata McGraw Hill, 2002.
2. Athanasios Papoulis, S. Unnikrishnan Pillai, Probability, Random Variables and Stochastic Processes, 4/e, Tata McGraw Hill, 2002.

References

1. Simon Haykin, Communication Systems, 4/e, Wiley Student Edition, 2006.
2. Henry Stark, John W. Woods, Probability and Random Processes with Application to Signal Processing, 3/e, Pearson Education, 2002.

Course Learning Outcomes:

Upon successful completion of this course, the student should be able to

- Analyze the outcomes of random experiments and develop the concept of random variables and obtain probabilities through them (L3)
- define single random variables in terms of their PDF and CDF, and calculate moments such as the mean and variance (L3)
- explore the random experiments specified by multiple random variables and study the Distribution of them (L4)
- apply the fundamentals of probability theory and random processes to practical engineering problems, and identify and interpret the key parameters that underlie the random nature of the problems (L5)

RANDOM PROCESSES

L	**T**	**P**	**C**
2	**0**	**0**	**2**

Preamble

This course is designed to impart knowledge on random processes needed in applications such as signal processing, digital communications, speech processing, data modelling, etc.

Course Objectives:

1. To familiarize the students in the concepts of probability and random variables.
2. To study Random Processes, its types, distribution, and density functions.
3. To study Gaussian and Poisson processes.
4. To apply random process to signal processing in communication systems.
5. To apply skills in analysing random phenomena which occur in Electrical and Electronics Engineering applications.

Unit-1: Random Processes: (6 hours)

Temporal characteristics - the random processes concept, Classification of random processes, stationarity and statistical independence. Time averages and Ergodicity.

Learning Outcomes:

At the end of this unit, the student will be able to:

- solve the problems on multiple random variables, joint distribution and statistical independence, (L1)
- understand the classifications of random processes and concepts such as strict stationarity, wide-sense stationarity (L2)
- apply the concept on time averages and ergodicity (L3)

Unit-2: Correlation and Covariance functions: (5 hours)

Auto correlation, Cross correlation, Properties. Covariance functions. Gaussian random processes, Poisson random processes:

Learning Outcomes:

At the end of this unit, the student will be able to:

- know the definition of auto correlation and its application(L1)
- to understand about the correlation functions(L2)
- demonstrate the specific applications to Poisson and Gaussian processes and representation of low pass and band pass noise model**s** (L2)

Unit-3: Density functions : (5 hours)

Probability density and joint probability density functions, Properties.

Learning Outcomes:

At the end of this unit, the student will be able to:

- know about joint probability density functions and its applications (L1)
- apply concept of joint density functions in random process (L3)
- apply the probability models and function of random variables based on single & multiple random variables (L3)

Unit-4:Spectral densities functions - I : **(5 hours)**

Spectral characteristics, the power density spectrum: Properties, relationship between power density spectrum and autocorrelation function

Learning Outcomes:

At the end of this unit, the student will be able to:

- understand the concept of power density functions (L2)
- apply substitution to compute power density function properties (L3)
- apply the concepts of power density functions and auto correlation (L3)

Unit-5 Spectral densities functions-II : **(5 hours)**

Cross-power density spectrum, Properties, relationship between cross power spectrum and cross-correlation function.

Learning Outcomes:

At the end of this unit, the student will be able to:

- develop an appreciation of the role of random processes in system modelling (L1)
- apply the concepts of filtering and prediction of a random process (L3)
- apply the specialised knowledge in random processes to solve practical engineering problems. (L3)

Course Outcomes:

At the end of the course, the student will be able to:

- solve the problems on multiple random variables, joint distribution and independence
- solve the problems Gaussian and Poisson processes
- understand the concept of random processes and determine covariance and spectral density of stationary random processes
- characterize the random signals in communication systems with their autocorrelation and power spectral density functions

Textbook (s)

1. Peyton Z. Peebles, Probability, Random Variables and Random Signal Principles, 4/e, Tata McGraw Hill, 2002.

References

1. Athanasios Papoulis, S. Unnikrishnan Pillai, Probability, Random Variables and Stochastic Processes, 4/e, Tata McGraw Hill, 2002.
2. Simon Haykin, Communication Systems, 4/e, Wiley Student Edition, 2006.
3. Henry Stark, John W. Woods, Probability and Random Processes with Application to Signal Processing, 3/e, Pearson Education, 2002.

OPTIMIZATION METHODS

L	T	P	C
2	0	0	2

Preamble:

Optimization is the art of finding the best result under given conditions. In this fast-expanding world, an engineer has to use many Optimization methods, as it is the most significant in decision-making, design, manufacturing, maintenance, planning, and scheduling.

Course Objectives: This course is designed to:

- introduce various optimization methods for solving real-world problems
- find optimal solutions to transportation, assignment, and sequencing problems
- know project planning and scheduling
- study the network analysis techniques through CPM and PERT

Unit – I **6 hours**

Transportation Problem: Introduction and LP formulation of Transportation Problem, feasible solution, basic feasible solution, finding Initial basic feasible solutions by North West corner rule, Least-cost entry method, Vogel's approximation method, Transportation Algorithm (MODI Method) to find an optimal solution.

Learning Outcomes:

After completion of this unit, the student will be able to:

- understand the problem of transportation problem (L2)
- find initial BFS by various methods (L3)
- apply MODI method for finding optimal transportation cost (L3)

Unit – II **5 hours**

Assignment Problems: Introduction to Assignment Problem, Mathematical formulation, Hungarian Method for finding optimal solution, unbalanced assignment problem, Travelling Salesman Problem.

After completion of this unit, the student will be able to:

- understand the problem of assignment problem(L2)
- apply the technique of solving the assignment problem using the Hungarian Method (L3)
- find an optimal solution to unbalanced assignment problem (L3)
- find the optimal route for the salesman (L3)

Unit – III **4 hours**

Sequencing Problem: Introduction, Basic terminology, Algorithms to obtain optimal solutions for sequencing problems with n jobs and two machines and n jobs and k machines.

Learning Outcomes:

After completion of this unit, the student will be able to:

- find optimal job sequencing (L3)
- find the optimal sequence for processing n jobs through two machines (L3)
- convert k machine problem into two machine problem (L4)
- find the optimal sequence for processing n jobs through k machines (L3)

Unit – IV **4 hours**

Network Analysis in Project planning: Project, Project Planning, Project Scheduling, Project Controlling, Work breakdown structure, Network Techniques, terms used in network-activity, event, path, network, dummy activity, looping, Fulkerson's rule, network diagram, and activity on node diagram.

Learning Outcomes :

By the end of this unit, the student will be able to:

- understand the problem of network models (L2)
- know the terms activity, node, labeling (L3)
- know the rules to draw the network diagram (L3)
- construct network diagram (L2)

Unit – V **7 hours**

PERT and CPM: Critical path method (CPM), Measure of activity, Critical path analysis, the four floats, subcritical and supercritical activities, slack, Programme evaluation and review technique (PERT), time estimates, frequency distribution curve for PERT

Learning Outcomes:

After completion of this unit, the student will be able to:

- know the technique of Critical Path Method (CPM) (L3)
- know the technique of PERT (L3)
- find time estimates (L3)
- estimate the probability of completing the project (L2)

Course outcomes:

On successful completion of this course, students will be able to:

- apply MODI method for finding optimal transportation cost
- apply Hungarian Method for solving assignment problems and finding an optimal route to the salesman
- understand the process of finding optimal sequencing for processing jobs on machines
- understand the network terminology and construction
- apply CPM and PERT techniques for project management

Text Books:

1. Operations Research by S.D.Sarma, Kedarnath, Ramnath and company, 15th edition, 2008.
2. Operations Research An Introduction by Hamdy A. Taha, 8th edition, Pearson, 2007.

Reference Books:

1. Linear Programming by R K Gupta, Krishna Prakashan Mandir, 13th edition 2014.
2. Operations Research Theory and Applications by J K Sharma, 4th edition, Macmillan Publishers India Ltd, 2009.

COMPUTATIONAL METHODS

L T P C
3 0 0 3

Preamble:
It is designed for the students for the basic understanding of techniques for numerical solution of algebraic equations, differentiation, integration used to solve engineering application problems.

Course Objectives:

- Develop the mathematical skills in the areas of numerical methods.
- Focus on the theory and applications of numerical methods in many engineering subjects which require solutions of linear systems, finding eigenvalues, eigenvectors, interpolation, and applications, solving ODEs, PDEs.
- Help in the foundation of computational mathematics for postgraduate courses, specialized studies, and research.
- Train in developing the codes for implementing the numerical methods using any programming languages.
- Formulate a mathematical model for a given engineering problem

UNIT I **9 hours**

Mathematical Modeling of Engineering Problems:
Approximations: Accuracy and precision, round-off and truncation errors, error problem with example problems. **Roots of Equations:** Formulations of linear and non-linear algebraic equations, solution with bisection, Newton-Raphson and Secant methods. Application to practical problems. **Algebraic Equations**: Formulation of linear algebraic equations from engineering problems, solution of these problems by Gauss elimination method, pitfalls of elimination and techniques for improving the solutions, Gauss Seidel iteration for solving sparse equations by avoiding storage of zero coefficients in matrix, convergence of iteration methods. LU decomposition methods for symmetric (Chelosky) matrices.

Learning Outcomes:

After completion of this unit the student will be able to

- Find the root for linear and non-linear algebraic equations by using iterative methods. (l1)
- Estimate the true error and approximate error between the iterations of the mathematical procedure. (l5)
- Formulate system of linear equations from engineering problem and solve using any of the numerical procedure(l6)

UNIT II **9 hours**

Eigenvalues and Eigenvectors Problems: Formulation of equations to column, truss, spring-mass and friction problems. Solutions for the largest and smallest eigenvalues and corresponding eigenvectors. **Interpolation Methods:** Polynomial interpolation, Lagrange interpolation polynomials with equi- spaced data. **Regression or Curve Fitting:** Linear regression by least squares method.

Learning Outcomes:

After completion of this unit the student will be able to

- Interpolate a polynomial with any given data(L4)
- Fit a curve using linear regression(L3)
- Calculate Eigenvalues and corresponding Eigenvectors for a given system of equations.(L3)

UNIT III 8 hours

Initial Value Problems: Ordinary differential equations, Euler, Heun's and Ralston methods. Runge- Kutta method of 2nd and 4th order, application to vibration and heat transfer problems. **Boundary Value Problems:** Linear and nonlinear ordinary differential equations, boundary value problems over semi-infinite domain, solution of nonlinear equations by finite difference method.

Learning Outcomes:

After completion of this unit the student will be able to

- Solve ODE's with R-K 2^{nd} and 4^{th} order methods. (L3)
- Interpret the boundary conditions for initial value and boundary value problems. (L2)
- Appreciate the merits of various numerical methods for solving ODE's.(L5)

UNIT IV 8 hours

Laplace Equations: Finite difference discretization of computational domain, different types of boundary conditions, solution to elliptic equations. **Parabolic Transient Diffusion Equations:** Explicit and implicit formulation, Crank Nicolson Method.

Learning Outcomes:

After completion of this unit the student will be able to

- Classify the given partial differential equation.(l2)
- Discretize the given domain by finite difference method for both elliptic and parabolic pde's. (l3)
- Apply the boundary conditions for any given problem satisfying the physics of the problem.(l2)

UNIT V 8 hours

Numerical Integration: Trapezoidal, Simpson's 1/3 and 3/8 rule and Gauss quadrature method.

Learning Outcomes:

After completion of this unit the student will be able to

- Solve the integration problem by using numerical methods. (l3)
- Understand the application of simpson's $1/3^{rd}$ and $3/8^{th}$ methods.(l2)

List of Computational Exercises:

1. Determine the real root for a given polynomial equation by (i) Bisection, (ii) Newton-Raphson until the approximate error falls below 0.5%.
2. Solve the system of simultaneous linear equations by

(i) Naïve -Gauss elimination
(ii) Gaussian elimination with partial pivoting
(iii) Gauss -Seidal method.
(iv) LU decomposition

3. Implement power method to find Eigenvalues and Eigenvectors for Spring mass system
4. Solve the parabolic partial differential equations by using explicit, implicit and semi-implicit methods
5. Solve the elliptic partial differential equations by finite difference techniques.
6. Finding the integral for a second-order polynomial using Gauss quadrature formula.
7. Solve numerical differentiation problems using Runge-Kutta 2^{nd} and 4^{th} order methods.
8. Find the integral by numerical methods such as Trapezoidal and Simpson's rule.

Course Outcomes:

At the end of the course, the student will be able to:

- Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems.
- Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations.
- Analyse and evaluate the accuracy of common numerical methods.
- Implement numerical methods using any programming language (matlab, scilab, python…)
- Write efficient, well-documented code and present numerical results in an informative way.

Text Book(s)

1. S.P. Venkateshan, P. Swaminathan, Computational Methods in Engineering, 1/e, Ane Publisher, 2014.
2. S.C. Chapra, R.P. Canale, Numerical Methods for Engineers, 6/e, Tata McGraw-Hill, 2012.

Reference

1. S.K. Gupta, Numerical Methods for Engineers, 1/e, New Age International, 2005.

PROBABILITY AND STATISTICS

L	T	P	C
3	0	0	3

Course Objectives:

- To familiarize the students with the foundations of probability and statistical methods
- To impart concepts in probability and statistical methods in engineering applications.

Unit I: Data Science and Probability **10 hrs**

Data Science: Statistics introduction, Population vs Sample, collection of data, primary and secondary data, types of variable: dependent and independent Categorical and Continuous variables, data visualization, Measures of central tendency, Measures of dispersion (variance).

Probability: Probability axioms, addition law and multiplicative law of probability, conditional probability, Baye's theorem (without proof).

Learning Outcomes:

At the end of this unit, the student will be able to

- summarize the basic concepts of data science and its importance in engineering (L3)
- analyze the data quantitatively or categorically , measure of averages, variability (L4)
- define the terms trial, events, sample space, probability, and laws of probability (L3)
- make use of probabilities of events in finite sample spaces from experiments (L3)
- apply Baye's theorem to real time problems (L3)

Unit II: Random Variable and Probability Distributions **8 hrs**

Random variables (discrete and continuous), probability density functions, probability distribution - Binomial, Poisson and normal distribution-their properties (mathematical expectation and variance).

Learning Outcomes:

At the end of this unit, the student will be able to

- explain the notion of random variable, distribution functions and expected value(L3)
- apply Binomial and Poisson distributions to compute probabilities, theoretical frequencies (L3)
- explain the properties of normal distribution and its applications (L3)

Unit III: Correlation, Regression and Estimation **8 hrs**

Correlation, correlation coefficient, rank correlation, regression, lines of regression, regression coefficients, principle of least squares and curve fitting (straight Line, parabola and exponential curves). **Estimation:** Parameter, statistic, sampling distribution, point estimation, properties of estimators, interval estimation.

Learning Outcomes:

At the end of this unit, the student will be able to

- identify different trends in scatter plots, strengths of association between two numerical variables (L3)
- make use of the line of best fit as a tool for summarizing a linear relationship and predicting future observed values (L3)
- estimate the value of a population parameter, computation of point and its interval (L3)

Unit IV: Testing of Hypothesis and Large Sample Tests **8 hrs**

Formulation of null hypothesis, alternative hypothesis, the critical region, two types of errors, level of significance, and power of the test. **Large Sample Tests**: Test for single proportion, difference of proportions, test for single mean and difference of means. Confidence interval for parameters in one sample and two sample problems

Learning Outcomes:

At the end of this unit, the student will be able to

- identify the difference between one- and two-tailed hypothesis tests (L3)
- analyze the testing of hypothesis for large samples (L4)

Unit V: Small Sample Tests **6 hrs**

Student t-distribution (test for single mean, two means and paired t-test), testing of equality of variances (F-test), $\chi 2$ - test for goodness of fit, $\chi 2$ - test for independence of attributes.

Learning Outcomes:

At the end of this unit, the student will be able to

- analyze the testing of hypothesis for small samples (L4)
- test for the Chi-square goodness of fit and independence of attributes (L4)

Text Books:

1. Miller and Freunds, Probability and Statistics for Engineers,7/e, Pearson, 2008.
2. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 11/e, Sultan Chand & Sons Publications, 2012.

References:

1. S. Ross, A First Course in Probability, Pearson Education India, 2002.
2. W. Feller, An Introduction to Probability Theory and its Applications, 1/e, Wiley, 1968.

Course Outcomes:

Upon successful completion of this course, the student should be able to

- classify the concepts of data science and its importance (L3)
- apply discrete and continuous probability distributions (L3)
- explain the association of characteristics through correlation and regression tools (L3)
- identify the components of a classical hypothesis test (L3)
- infer the statistical inferential methods based on small and large sampling tests (L4)

MECH1011: ENGINEERING VISUALIZATION AND PRODUCT REALIZATION

L	T	P	C
0	**0**	**4**	**2**

The course enables the students to convey the ideas and information graphically that come across in engineering. This course includes projections of lines, planes, solids sectional views, and utility of drafting and modelling packages in orthographic and isometric drawings.

Course Objectives

- Create awareness of the engineering drawing as the language of engineers.
- Familiarize how industry communicates, practices for accuracy in presenting the technical information.
- Develop the engineering imagination essential for successful design.
- Train in 2D and 3D modeling softwares.
- Teach assembly of simple components and their animation.
- Teach basic 3D printing software for preparation of simple components

Manual Drawing: **(8 P hours)**

Introduction to Engineering graphics: Principles of Engineering Graphics and their significance-Conventions in drawing-lettering - BIS conventions. Dimensioning, sectioning and datum planes

Free hand sketching **(4 P hours)**

Free hand sketching of isometric & orthographic views and interpretation of drawings.

Computer Aided Drafting **(12 P hours)**

Introduction to CAD software: Basic drawing and editing commands: line, circle, rectangle, erase, view, undo, redo, snap, object editing, moving, copying, rotating, scaling, mirroring, layers, templates, polylines, trimming, extending, stretching, fillets, arrays, dimensions. Dimensioning principles and conventional representations.

Assemble drawings **(12 P hours)**

Constraints and assembly drawings. Engineering animation including motion curves, coordinating multiple moving parts under joint-constraints and the notion and impact of lighting and camera.

3D printing **(8 P hours)**

introduction to 3D printing software. slicing, grading and rendering of simple geometries using software

Project by group of students in the following themes **(12 P hours)**

IC engine model and 3D printed mini model
Belt drive for a bike
Four-wheel drivable ATV robot
Toy making - Carrom board, chess board & pieces model toy train, avengers
Buildings, bridges dams etc.
Wind turbine model
Design of Programmable Intelligent Controllers – PIC
Design of Printed Circuit Boards
Arduino Board Design and 3D Printing of Enclosures for Arduino Boards
Design of Radar and 3D Printing of Radar Models
Design of Mini Motherboards

Course Outcomes

After completing the course, the student will be able to

- utilize Engineering visualization as Language of Engineers. (L3)
- prepare drawings as per international standards. (L3)
- create 2D and 3D models using CAD packages. (L3)
- use 3D printing software and create model for printing of simple objects

MECH1021: WORKSHOP

L	T	P	C
0	0	4	2

This course enables the students to familiarize with the basic fabrication practices and to explore the various devices, tools and equipment used. Hands-on exercise is provided in various trade sections. Essentially student should understand the labor involved, machinery or equipment necessary, time required to fabricate and should be able to estimate the cost of the product or job work which are fundamental tasks for engineering plans.

Course Objectives

- Explain tools used in carpentry, fitting and sheet metal and practice procedure of doing experiments.
- Make the students to learn types of basic electric circuit connections and PCBs.
- Provide training to prepare FRP composites.
- Train the students on preparing 3D plastics using injection molding.
- Demonstrate on utilizing 3D printer for printing 3D objects

List of Jobs

1. Wood Working - Cross halving Joint/Dove Tail Joint/End Bridle Joint (Any two)
2. Sheet Metal working - Taper tray/conical funnel/Elbow pipe (Any Two) (including soldering).
3. Fitting- V fit/Dove Tail fit/ Semicircular fit (Any Two)
4. Electrical Wiring -Parallel and series connection
5. Electrical Wiring -Two-way switch connection
6. Electrical Wiring- Wiring of lighting systems
7. Injection molding-Make any two plastic components using injection molding machine.
8. 3D printing Demonstartion

Text Books

1. P. Kannaiah, K. L. Narayana, 'Workshop Manual', 2/e, Scitech Publications, India, 2007.
2. B. L Juneja , 'Workshop Practice ', 1/e, Cengage Learning ,Delhi, 2015

Additional Reading

1. K Mallick, 'Fiber-Reinforced Composites: Materials, Manufacturing, and Design', 3/e, CBC Press, New York, 2007.

Course Outcomes:

After completion of this lab the student will be able to

- Summarize application of different power tools (L1)
- Develop different parts with metal sheet/wood working/fits in real time applications. (L3)
- Demonstrate electrical circuits in various applications. (L2)
- Prepare models using injection molding m/c . (L3)
- Familiarize with 3D printer operations (L1)

MECH1031: DESIGN THINKING

L	T	P	J	S	C
0	0	2	0	0	1.0

Course Pre-requisite(s):Engineering Visualization and Product Realization
Design is a realization of a concept or idea into a configuration, drawing or product. Design Thinking is the cognitive and practical process by which design concepts are developed by designers. Innovation is a new idea or a new concept. Product development is the creation of a new or different product that offers new benefits to the end-user. This course introduces design thinking in product innovation.

Course Objectives
1. To familiarize the product design process
2. To introduce the basics of design thinking
3. To bring awareness on idea generation
4. To familiarize the role of design thinking in services design

Topic	Type
Each member of the group has to ask (vocally) the group members different questions about a product that they would like to design. Write down the questions and answers and submit as a word or pdf document.	Exercise
Each member of the group must ask (vocally) the group members questions about the product chosen in the previous experiment. This helps to gain indepth insights as well as new findings and information in order to grasp the problem or situation holistically or simply to find relevant questions for an interview. Write down the questions and answers and submit as a word or pdf document	Exercise
Identify relevant factors of influence that constitute the basis for a new or improved product or offer; then analyze it in a targeted manner. ➢ Make sure that you are sufficiently creative in the analysis process, because the focus is on technical “details”. ➢ Boost the efficiency of the analysis process by avoiding empty runs. ➢ Make use of a standardized procedure in order to examine the problem and solution space again with the help of data.	Exercise
➢ Do research, talk with people, and have empathy to formulate profound stories. ➢ Summarize the results from the “understand” and “observe” phases and discuss with the team. ➢ Highlight unexpected results and generate new perspectives. ➢ In general, share insights, ideas, and results (solutions) with others.	Exercise
➢ Explore untapped market opportunities. ➢ Provide differentiated and new offers based on the user needs. ➢ Adapt a strategy to new market needs by understanding the competitive edge. ➢ Establish the right vision for the design challenge or a road map for stepby-step implementation and control mechanisms.	Exercise
➢ Find out at an early stage whether the basic need is satisfied and the product attracts interest on the market. ➢ Find out through iterative testing whether the user need is met with a minimally functional product and how the product should be enhanced. ➢ Find out through user feedback how much demand there is for the product before developing further details and features. ➢ Minimize the risk of investing in a solution for which there is little demand on the market, thus saving time, money, and energy.	Exercise

➢ Perform a true A/B test or several variants of a prototype in the form of a multi-variants test or as split testing. ➢ Do a quantitative evaluation. ➢ Carry out a qualitative survey and evaluate the number and content of feedbacks. ➢ Compare individual variants of a function or a prototype (e.g. buttons, visuals, arrangement).	Exercise
➢ Collect and appraise experiences made in the project in a structured manner. ➢ Learn from experience and make use of it in the next project. ➢ Facilitate a positive attitude toward mistakes and appreciate progress. ➢ Identify and document the findings; make them applicable and usable.	Exercise
Case Studies : Example : Software Prototyping, Additive Manufacturing; Design of Arduino Boards for various applications etc	Exercise

Texbook(s)	**Topics**
1. Pahl, Beitz, Feldhusen, Grote,'Engineering Design: a systematic approach',3rd,Springer Science & Business Media,London,2007,978-1846283185	All Exercises
2. Christoph Meinel,Larry Leifer,Hasso Plattner,'Design Thinking Understand – Improve – Apply',1st,Springer,Berlin, Heidelberg,2011,978-3-642-13756-3	All Exercises

Additional Reading(s)	**Topics**
1. Marc Stickdorn, Jakob Schneider,'This is Service Design Thinking: Basics, Tools, Cases',1st,WILEY,United States,2012,978-1-118-15630-8	All Exercises

Journal(s)	**Topics**

Website(s)	**Topics**

Course Outcomes(COs)

1 Innovate new methods in product development
2 2 Apply Design Thinking in developing the new designs
3 Select ideas from ideation methods in new product development
4 Use Design Thinking in developing software products
5 Apply principles of Design Thinking in service design

CSEN1011 - PROBLEM SOLVING AND PROGRAMMING WITH C

L	T	P	C
0	0	6	3

The course is designed to enable the student to write programs for problem solving. After an introduction to program logic design using algorithms and flowcharts, converting the logic into programs is taught. The features of structured programming are explained with the C programming language as an example. This course lays the foundation both for developing program logic and for writing programs in C according to the developed logic.

Course Objectives:

1. Familiarize the student with the steps involved in writing and running a compiled program.
2. Enable the student to build program logic with algorithms and flowcharts.
3. Explain with the features and constructs of C programming such as data types, expressions, loops, functions, arrays, pointers, and files.
4. Demonstrate the handling of variables and input-output operations in C.
5. Train the student to convert program logic into C language code using a top-down approach.

Module I: Introduction to Computer Problem-Solving 12 P

Introduction, the Problem-Solving Aspect, Top-Down Design, Introduction to the idea of an algorithm, Introduction to Flowchart using Raptor tool.

Introduction to C Language – Structure of a C Program, Keywords, Identifiers, Data Types (int, float, char, unsigned int) and Variable declaration, Constants, Input / Output function. Operators, Expressions, Precedence and Associativity, Expression Evaluation, Type conversions.

Exercises: Construct a flowchart and write a program to

- Develop a calculator to convert time, distance, area, volume and temperature from one unit to another.
- Calculate simple and compound interest for various parameters specified by the user
- To enter marks of five subjects and calculate total, average and percentage.
- Calculate net salary of employee given basic,da,hra,pf and lic
- retrieve remainder after division of two numbers without using mod operator
- Convert an upper-case character to a lower-case character.
- Swap two numbers
- Enter two angles of a triangle and find the third angle.
- Check Least Significant Bit (LSB) of a number
- Input any number from user and check whether nth bit of the given number is set (1) or not (0)(hint: Use bitwise operators)

Learning Outcomes

After completion of this unit the student will be able to

- Develop algorithms and basic flowcharts for performing Input, Output and Computations (L3)
- Interpret the structure of C program and various key features of C (L2)
- Translate mathematical expressions to C notation using operators (L2).

Module II: Control Structures 15 P

- **Control Structures:** Selection Statements (making decisions) – if, if-else, nested if, else if ladder and switch statements. Repetition statements (loops)-while, for, do-while statements, Nested Loops.
- Unconditional statements-break, continue, goto.
- Pointers – Pointer variable, pointer declaration, Initialization of pointer, accessing variables through pointers, pointers to pointers, pointers to void.

Exercises: Construct a Flowchart and Write a Program to

- Check whether the triangle is equilateral, isosceles, or scalene triangle.
- Check whether entered year is a leap year or not
- Find minimum among three numbers.
- Check whether a number is divisible by 5 and 11 or not.
- Check whether a number is positive, negative or zero using switch case.
- Design a calculator that performs arithmetic operations on two numbers using switch case
- Find Roots of a Quadratic Equation
- Find factorial of a number
- Check whether number is a palindrome or not
- Check whether number is perfect or not
- Convert a decimal number to binary number
- To find the sum of the series [1-X^2/2!+X^4/4!- ....].
- Print following patterns

```
*
*
* *
* * *
* * * *

A
B B
C CC
D D D D
E E E EE

1
2 3
4 5 6
7 8 9 10
```

- Calculate the greatest common divisor of two numbers
- Generate first n numbers in the Fibonacci series
- Generate n prime numbers
- Swap two numbers using pointers.
- Performs all the five arithmetic operations using Pointers.

Learning Outcomes:

After completion of this unit the student will be able to

- Construct C programs using various conditional statements (L3).

- Develop C programs using loops and nested loops (L6).
- Demonstrate the usage of pointers (L3).

Module III: Functions 15 P

Functions-Designing Structured Programs, user defined function- function definition, function prototype, function call, Types of functions. Parameter Passing by value, parameter passing by address, Recursive functions. Dynamic Memory allocation Functions, pointers to functions. Storage classes-auto, register, static, extern.

Exercises: Write a program using functions to

- Print even and odd numbers in a given range
- Find power of a number
- Return maximum of given two numbers
- To print all strong numbers between given interval using functions.
- Check whether a number is prime, Armstrong or perfect number using functions.
- Demonstrate call by value and call by reference mechanisms.
- Find power of any number using recursion.
- Generate Fibonacci series using recursion
- Find product of two numbers using recursion
- Find the sum of digits of a number. Number must be passed to a function using pointers.
- Find GCD (HCF) of two numbers using recursion.
- Find LCM of two numbers using recursion.

Learning Outcomes:

After completion of this unit the student will be able to

- understand the concept of subprograms and recursion (L2).
- apply the in-built functions to develop custom functions for solving problems (L3).
- make use of parameter passing mechanisms (L3).
- infer the effect of storage classes on variables (L2).

Module IV: Arrays and Strings 15 P

Arrays – Declaration and Definition of Array, accessing elements in array, Storing values in array, linear search, binary search, bubble sort, Two – dimensional arrays, multidimensional arrays. Arrays and Pointers, Pointer Arithmetic and arrays, array of pointers, Passing array to function. Strings – Declaration and Definition of String, String Initialization, unformatted I/O functions, arrays of strings, string manipulation functions, string and pointers.

Exercises: Write a program to

- Find minimum and maximum element in an array
- Implement linear search.
- Sort an array in descending order.
- Given a two-dimensional array of integers and a row index, return the largest element in that row.
- Find transpose of a matrix.
- Perform multiplication of two matrices
- Count total number of vowels and consonants in a string.
- Reverse the given string without using String handling functions.
- Sort strings in dictionary order

- To perform addition of two matrices.
- Read an array of elements of size ‘n’ and find the largest and smallest number using functions
- find total number of alphabets, digits or special character in a string using function

Learning Outcomes:

After completion of this unit the student will be able to

- develop programs for storing and managing collections of items using arrays (L3).
- make use of the in-built functions to manipulate strings (L3).
- solve problems related to arrays and strings (L3).

Module V: Structures and Files 15 P

Structures–Declaration, initialization, accessing structures, operations on structures, structures containing arrays, structures containing pointers, nested structures, self-referential structures, arrays of structures, structures and functions, structures and pointers, unions.

Files – Concept of a file, Opening and Closing files, file input / output functions (standard library input / output functions for text files)

Exercises: Write a program to

- Store information of a student using structure
- Add two complex numbers by passing structures to a function
- Store information of 10 students using structures
- Store Employee information using nested structure
- Read file contents and display on console.
- Read numbers from a file and write even and odd numbers to separate file.
- Count characters, words and lines in a text file.

Learning Outcomes:

After completion of this unit, the student will be able to:

- develop programs using structures and unions for storing dissimilar data items (L6).
- compare the utilization of memory by structures and unions (L5).
- make use of files and file operations to store and retrieve data (L3).

Text Books(s)

1. B. A. Forouzan and R. F. Gilberg, Computer Science: A Structured Programming Approach Using C, 3/e, Cengage Learning

Reference Book(s)

1. Jeri R Hanly, Elliot B Koffman, Problem Solving and Program Design in C, 7/e, Pearson Education, 2012.
2. B.W. Kernighan and Dennis M. Ritchie, The C Programming Language, 2/E, Pearson education, 2015.
3. B. Gottfried, Programming with C, 3/e, Schaum’s outlines, McGraw Hill (India), 2017.
4. P. Dey and M Ghosh, Programming in C, 2/e, Oxford University Press, 2011.

Course Outcomes:

After completion of this course the student will be able to

- Build logic for solving a problem and translate it into a program. (L3).
- Define variables and construct expressions using C language (L1).
- Utilize arrays, structures and unions for storing and manipulating data (L3).
- Develop efficient, modular programs using functions (L3).
- Write programs to store and retrieve data using files (L3).

Additional Exercises:

- Given numbers x, y, and target, return whichever of x and y is closer to the target. If they have the same distance, return the smaller of the two
- There are three friends Ram, Raheem and Robert. Ram's age is 20, Raheem is aged three times more than his friend Ram. After 8 years, he would be two and a half times of Ram's age. After further 8 years, how many times would he be of Rams age? Robert's age is 25 now. Now program your computer to determine the final ages of all the three people after 16 years and also show who is elder.
- Given an actual time and an alarm clock time, both in "military" format (such as 0730 for 7:30am), print how many more minutes before the alarm rings. But if the time is after the alarm, print "Alarm already went off".
- Let there be a scenario where you and your friend are going to a restaurant. You have lunch there every fourth day, and he has his lunch there every sixth day. How many days before you meet again for lunch at the same restaurant?
- Two friends Suresh and Ramesh have **m** red candies and **n** green candies respectively. They want to arrange the candies in such a way that each row contains equal number of candies and also each row should have only red candies or green candies. Help them to arrange the candies in such a way that there are maximum number of candies in each row.
- On a chessboard, positions are marked with a letter between a and h for the column and a number between 1 and 8 for the row. Given two position strings, return true if they have the same colour.
- Given two strings s0 and s1, return whether they are anagrams of each other.
- Write a program to encrypt and decrypt a password which is alphanumeric
- Given a string, return the string with the first and second half swapped. If the string has odd length, leave the middle character in place.
- Given an array of integers, return the second-largest element.
- Given lists of integers people, jobs, profits. Each person i in people have people[i] amount of strength, and performing job j requires jobs[j] amount of strength and nets profits[j] amount of profit. Given that each person can perform at most one job, although a job can be assigned to more than one person, return the maximum amount of profit that can be attained.
- Mr. Roxy has arranged a party at his house on the New Year's Eve. He has invited all his friends - both men and women (men in more number). Your task is to generate the number of ways in which the invitees stand in a line so that no two women stand next to each other. Note that the number of men is more than the number of women and Roxy doesn't invite more than 20 guests. If there are more than 20 guests or an arrangement as per the given constraints is not possible, print 'invalid'.
- Two friends have entered their date of birth and they want to know who is elder among them. Make a structure named Date to store the elements day, month and year to store the dates.

Case Study:

- Create a structure containing book information like accession number, name of author, book title and flag to know whether book is issued or not. Create a menu in which the following functions can be done: Display book information, Add a new book, Display all the books in the library of a particular author, Display the number of books of a particular title, Display the total number of books in the library, Issue a book (If we issue a book, then its number gets decreased by 1 and if we add a book, its number gets increased by 1)
- Ranjan is maintaining a store. Whenever a customer purchases from the store, a bill is generated. Record the customer name, amount due, the amount paid, mobile number with purchased items in file. At the end of day print the total income generated by store.
- Contact Management System- Create structure to store Contact information like name,gender,mail,phone number and address. Users can add new contact and can also edit and delete existing contact. (Hint: Use Files to store data)

CSEN1021 - PROGRAMMING WITH PYTHON

L	T	P	C
0	0	6	3

Course Objectives:

- To elucidate problem solving through python programming language
- To introduce function-oriented programming paradigm through python
- To train in development of solutions using modular concepts
- To teach practical Python solution patterns

Module I: Introduction to Python **12 H**

Python – Numbers, Strings, Variables, operators, expressions, statements, String operations, Math function calls, Input/output statements, Conditional If, while and for loops.

Exercises:

- Accept input from user and store it in variable and print the value.
- Use of print statements and use of (.format)for printing different data types.
- Take 2 numbers as user input and add, multiply, divide, subtract, remainder and print the output (Same operations on floating point input as well)
- Conversion of one unit to another (such as hours to minutes, miles to km and etc)
- Usage of mathematical functions in python like math.ceil, floor, fabs, fmod, trunc, pow, sqrt etc.
- Building a mathematical calculator that can perform operations according to user input. Use decision making statement.
- Accepting 5 different subject marks from user and displaying the grade of the student.
- Printing all even numbers, odd numbers, count of even numbers, count of odd numbers within a given range.
    - Compute the factorial of a given number. b) Compute GCD of two given numbers. c) Generate Fibonacci series up to N numbers.
- Check whether the given input is a) palindrome b) strong c) perfect
- Compute compound interest using loop for a certain principal and interest amount

Learning Outcomes:

After completion of this unit the student will be able to

- solve simple problems using control structures, input and output statements. (L3)
- develop user defined functions (recursive and non-recursive). (L3)

Module II: Functions **15H**

User defined Functions, parameters to functions, recursive functions. Lists, Tuples, Dictionaries, Strings.

Exercises:

- Create a function which accepts two inputs from the user and compute ${}^{n}C_{r}$
- Recursive function to compute GCD of 2 numbers
- Recursive function to find product of two numbers
- Recursive function to generate Fibonacci series
- Program to print a specified list after removing the 0th, 4th and 5th elements. Sample List : ['Red', 'Green', 'White', 'Black', 'Pink', 'Yellow'] Expected Output : ['Green', 'White', 'Black']
- Program to get the difference between the two lists.
- Program to find the second smallest number and second largest number in a list.
- Given a list of numbers of list, write a Python program to create a list of tuples having first element as the number and second element as the square of the number.
- Given list of tuples, remove all the tuples with length K.
  Input : test_list = [(4, 5), (4,), (8, 6, 7), (1,), (3, 4, 6, 7)], K = 2
  Output : [(4,), (8, 6, 7), (1,), (3, 4, 6, 7)]
  Explanation : (4, 5) of len = 2 is removed.
- Program to generate and print a dictionary that contains a number (between 1 and n) in the form (x, x*x).
  Sample Input: (n=5) :
  Expected Output : {1: 1, 2: 4, 3: 9, 4: 16, 5: 25}
- Program to remove a key from a dictionary
- Program to get the maximum and minimum value in a dictionary.
- Program to perform operations on string using unicodes ,splitting of string,accessing elements of string using locations
- Program for Counting occurrence of a certain element in a string, getting indexes that have matching elements.For ex -.In Rabbit count how many times b has occurred . Example-I have to go to a doctor and get myself checked. Count the number of occurrences of ‘to’.
- Program for replacing one substring by another For example - Rabbit - Replace ‘bb’ by ‘cc’
- Program to Acronym generator for any user input (ex-input is Random memory access then output should be RMA).Example - Random number (RN)
- Python function that accepts a string and calculates the number of uppercase letters and lowercase letters.
- Program to count the number of strings where the string length is 2 or more and the first and last character are same from a given list of strings
- Sample List : ['abc', 'xyz', 'aba', '1221'] Expected Result : 2

Learning Outcomes:
After completion of this unit the student will be able to

- understand the concept of subprograms and recursion (L2).
- apply the in-built functions to develop custom functions for solving problems (L3).
- make use of parameter passing mechanisms (L3).
- develop user defined functions (recursive and non-recursive). (L3)
- summarize the features of lists, tuples, dictionaries, strings and files. (L2)

Module III: Files and Packages **15 H**

Files—Python Read Files, Python Write/create Files, Python Delete Files.
Pandas -- Read/write from csv, excel, json files, add/ drop columns/rows, aggregations, applying functions.
Exercises

- read an entire text file.
- read the first n lines of a file.
- append text to a file and display the text.
- Read numbers from a file and write even and odd numbers to separate files.
- Count characters, words and lines in a text file.
- To write a list to a file.
- Given a CSV file or excel file to read it into a dataframe and display it.
- Given a dataframe, select rows based on a condition.
- Given is a dataframe showing the name, occupation, salary of people. Find the average salary per occupation.
- To convert Python objects into JSON strings. Print all the values.
- Write a Pandas program to read specific columns from a given excel file.

Learning Outcomes:
After completion of this unit the student will be able to

- read data from files of different formats and perform operations like slicing, insert, delete, update(L3).
- Ability to define and use of Packages(L2).

Module IV: Operations in database with suitable libraries **15 H**

SQLite3: CRUD operations (Create, Read, Update, and Delete) to manage data stored in a database. Matplotlib -- Visualizing data with different plots, use of subplots. User defined packages, define test cases.

Exercises

Special commands to sqlite3 (dot-commands)
Rules for "dot-commands"
Changing Output Formats
Querying the database schema
Redirecting I/O
Writing results to a file
Reading SQL from a file
File I/O Functions
The edit() SQL function
Importing CSV files
Export to CSV

Export to Excel
Reference - https://www.sqlite.org/cli.html
Matplotlib can be practiced by considering a dataset and visualizing it.
It is left to the instructor to choose appropriate dataset.

Learning Outcomes:
After completion of this unit the student will be able to
- visualize the data (L4).
- Understanding the various operations performed with SQLite3. (L2)
- make use of SQLite3 operations to store and retrieve data (L3).

Module V: Regular Expressions **15 H**
Regular expression: meta character, regEx functions, special sequences, Web scrapping, Extracting data.
Exercises
Write a Python program to check that a string contains only a certain set of characters (in this case a-z, A-Z and 0-9).
Write a Python program that matches a string that has an a followed by zero or more b's
Write a Python program that matches a string that has an a followed by one or more b's
Write a Python program that matches a string that has an a followed by zero or one 'b'
Write a Python program that matches a string that has an a followed by three 'b'
Write a Python program to find sequences of lowercase letters joined with an underscore
Write a Python program to test if a given page is found or not on the server.
Write a Python program to download and display the content of robot.txt for en.wikipedia.org.
Write a Python program to get the number of datasets currently listed on data.gov
Write a Python program to extract and display all the header tags from en.wikipedia.org/wiki/Main_Page
Learning Outcomes:
After completion of this unit, the student will be able to:
- make use of Web scrapping operations (L3).
- Use regular expressions to extract data from strings.(L3)

Text Books(s)
1. Programming with python, T R Padmanabhan, Springer
2. Python Programming: Using Problem Solving Approach, Reema Thareja, Oxford University Press

Reference Book(s)
1. Programming with python, T R Padmanabhan, Springer
2. Python Programming: Using Problem Solving Approach, Reema Thareja, Oxford University Press
3. Python for Data Analysis, Wes McKinney, O.Reeilly

Course Outcomes:
- After completion of this course the student will be able to
- Define variables and construct expressions (L1).
- Utilize arrays, storing and manipulating data (L3).
- Develop efficient, modular programs using functions (L3).
- Write programs to store and retrieve data using files (L3).

APPLICATIONS OF ARTIFICIAL INTELLIGENCE

L T P C
0 0 2 1

The surge in the production of data has led to the development of various technologies. The term "Artificial Intelligence (AI)" has become ubiquitous in everyday applications from virtual assistants to self-driving cars. Several applications such as Healthcare, Finance, Bioinformatics etc. are benefitting from the advances in the domain. The global market for artificial intelligence is going to face a phenomenal growth over the coming years with organizations across the world capitalizing on the disruptive technologies that AI is offering. This course introduces the recent applications of AI namely, Virtual Assistants, Computer Vision, along with trending topics such as Deep Learning and Reinforcement Learning. The idea of the course is to introduce the basic concepts of AI as well as latest trends in the domain. This course is envisaged to provide a basic understanding on latest developments of AI to all disciplines engineering undergraduates.

Course Objectives:

- Provide introduction to basic concepts of artificial intelligence.
- Explore applications of AI
- Explore the scope, advantages of intelligent systems
- Experiment with different machine learning concept
- Exposure to AI-intensive computing and information system framework

Week-1: 2 L

Introduction to Artificial intelligence: Basics of AL Agents and Environment, The Nature of Environment.

List of Experiment(s):

1. Implementation of toy Problems (8-Puzzle,Wumpus World, Vacuum-clean Example, etc)

Week-2: 2 P

Applications of AI: Game Playing, [Deep Blue in Chess, IBM Watson in Jeopardy, Google's Deep Mind in AlphaGo]

List of Experiment(s):

1. Implementation of (Sudoku, Crossword Puzzle, or WumpusWorld, etc)

Learning Outcomes:

The student will be able to:

- Understand the basics in AI.
- Recognize various domains in AI.

Week-3: 2 P

Conceptual introduction to Machine Learning: Supervised, Unsupervised, and Semi-Supervised Learning.

List of Experiment(s):

1. Supervise - Perform Data Labelling for various images using object recognition

Week-4: 2 P

Reinforcement Learning, Introduction to Neural Networks, Deep Learning.

List of Experiment(s):

1. Explore the effect of different hyperparameters while implementing a Simple Fully Connected Neural Network. (https://playground.tensorflow.org)

Learning Outcomes:
The student will be able to:

- Define machine learning and forms of learning
- Identify types of Neural Networks

Week-5: 2 P

Image Processing & Computer Vision: Introduction to Image processing, Image Noise, Removal of Noise from Images, Color Enhancement, Edge Detection.

List of Experiment(s):

1. Lobe.ai - Build custom models using the visual tool for Object recognition and sentiment analysis that can convert facial expressions into emoticons

Week-6: 2 P

Segmentation. Feature Detection & Recognition. Classification of images. Face recognition, Deep Learning algorithms for Object detection & Recognition.

List of Experiment(s):

1. Teachable Machine Brain.JS In Browser Object Recognition through
2. Haar Cascade Object detection for Eye and Face in Python using Open CV

Learning Outcomes:
The student will be able to:

- Identify the concepts of image processing
- Implement the methods in computer vision

Week-7: 2 P

Conceptual introduction to Natural Language Processing: Speech Recognition & Synthesis: Speech Fundamentals, Speech Analysis, Speech Modelling.

List of Experiment(s):

1. Sentiment Analysis and Polarity detection

Week-8: 2 P

Speech Recognition, Speech Synthesis, Text-to-Speech, Sentiment Analysis, Segmentation and recognition.

List of Experiment(s):

1. Text to Speech recognition and Synthesis through APIs

Learning Outcomes:
The student will be able to:

- Understand the basics of Speech Processing
- Describe natural language processing and concepts for converting speech to different forms

Week-9: 2 P

Introduction to o Chatbot, Architecture of a Chatbot. NLP in the cloud, NL Interface, How to Build a Chatbot, Transformative user experience of chatbots, DesigningElements of a chatbot, Best practices for chatbot development. NLP components. NLP wrapper to chatbots. Audiobots and Musicbots.

List of Experiment(s):

1. Building a Chatbot using IBM Watson visual studio
2. Building a Chatbot using Pandora bots
3. Build a virtual assistant for Wikipedia using Wolfram Alpha and Python

Learning Outcomes:
The student will be able to:

- Understand basic architecture of chatbots.
- Implement chatbots for various applications.

Week-10: 2 P

Smart Applications: Smart Manufacturing, Smart Agriculture, Smart Healthcare, Smart Education, Smart Grids, Smart Transportation andAutonomous Vehicles, Smart Homes, Smart Cities

List of Experiment(s):

1. Build a smart application specific to the domain of the student.

Learning Outcomes:

The student will be able to:

- Understand the application of intelligence in various domains
- Correlate Artificial Intelligence to advanced applications

Text Books(s)

1. Tom Markiewicz& Josh Zheng, Getting started with Artificial intelligence, Published by O'Reilly Media,20l7
2. Stuart J. Russell and Peter Norvig, Artificial Intelligence A Modern Approach.

Reference Book(s)

1. Aurtlien Giron. Hands on Machine Learning with Scikit-Learn and TensorFlow concepts,Tools, and Techniques to Build intelligent Systems , Published by O'Reilly Mcdia,20l 7
2. Build an AI Assistant with wolfram alpha and Wikipedia in python.https://medium .com/@salisuwy/build-an-ai-assistant-with-wolfram-alpha-and-wikipedia-in-python-d9bc8ac838fe.
3. Joseph Howse, Prateek Joshi, Michael Beyeler - Opencv Computer Vision Projects withPython-Publishing (201 6).
4. Curated datasets on kaggle https://www.kaggle.com/datasets.

Course Outcomes:

- Able to grasp the concepts of artificial intelligence, machine learning, natural language processing, image processing
- Recognize various domains in which Al can be applied
- Implement the methods in processing an image:
- Implement simple of chatbots
- identify smart applications:

PROBABILITY AND STATISTICS

L	T	P	C
3	0	0	3

Course Objectives:

- To familiarize the students with the foundations of probability and statistical methods
- To impart concepts in probability and statistical methods in engineering applications.

Unit I: Data Science and Probability **10 hrs**

Data Science: Statistics introduction, Population vs Sample, collection of data, primary and secondary data, types of variable: dependent and independent Categorical and Continuous variables, data visualization, Measures of central tendency, Measures of dispersion (variance).

Probability: Probability axioms, addition law and multiplicative law of probability, conditional probability, Baye's theorem (without proof).

Learning Outcomes:

At the end of this unit, the student will be able to

- summarize the basic concepts of data science and its importance in engineering (L3)
- analyze the data quantitatively or categorically , measure of averages, variability (L4)
- define the terms trial, events, sample space, probability, and laws of probability (L3)
- make use of probabilities of events in finite sample spaces from experiments (L3)
- apply Baye's theorem to real time problems (L3)

Unit II: Random Variable and Probability Distributions **8 hrs**

Random variables (discrete and continuous), probability density functions, probability distribution - Binomial, Poisson and normal distribution-their properties (mathematical expectation and variance).

Learning Outcomes:

At the end of this unit, the student will be able to

- explain the notion of random variable, distribution functions and expected value(L3)
- apply Binomial and Poisson distributions to compute probabilities, theoretical frequencies (L3)
- explain the properties of normal distribution and its applications (L3)

Unit III: Correlation, Regression and Estimation **8 hrs**

Correlation, correlation coefficient, rank correlation, regression, lines of regression, regression coefficients, principle of least squares and curve fitting (straight Line, parabola and exponential curves). **Estimation:** Parameter, statistic, sampling distribution, point estimation, properties of estimators, interval estimation.

Learning Outcomes:

At the end of this unit, the student will be able to

- identify different trends in scatter plots, strengths of association between two numerical variables (L3)
- make use of the line of best fit as a tool for summarizing a linear relationship and predicting future observed values (L3)
- estimate the value of a population parameter, computation of point and its interval (L3)

Unit IV: Testing of Hypothesis and Large Sample Tests **8 hrs**

Formulation of null hypothesis, alternative hypothesis, the critical region, two types of errors, level of significance, and power of the test. **Large Sample Tests**: Test for single proportion, difference of proportions, test for single mean and difference of means. Confidence interval for parameters in one sample and two sample problems

Learning Outcomes:

At the end of this unit, the student will be able to

- identify the difference between one- and two-tailed hypothesis tests (L3)
- analyze the testing of hypothesis for large samples (L4)

Unit V: Small Sample Tests **6 hrs**

Student t-distribution (test for single mean, two means and paired t-test), testing of equality of variances (F-test), $\chi 2$ - test for goodness of fit, $\chi 2$ - test for independence of attributes.

Learning Outcomes:

At the end of this unit, the student will be able to

- analyze the testing of hypothesis for small samples (L4)
- test for the Chi-square goodness of fit and independence of attributes (L4)

Text Books:

1. Miller and Freunds, Probability and Statistics for Engineers,7/e, Pearson, 2008.
2. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 11/e, Sultan Chand & Sons Publications, 2012.

References:

1. S. Ross, A First Course in Probability, Pearson Education India, 2002.
2. W. Feller, An Introduction to Probability Theory and its Applications, 1/e, Wiley, 1968.

Course Outcomes:

Upon successful completion of this course, the student should be able to

- classify the concepts of data science and its importance (L3)
- apply discrete and continuous probability distributions (L3)
- explain the association of characteristics through correlation and regression tools (L3)
- identify the components of a classical hypothesis test (L3)
- infer the statistical inferential methods based on small and large sampling tests (L4)

EECE1001: BASIC ELECTRICAL AND ELECTRONICS ENGINEERING

L	T	P	C
2	1	2	4

This course introduces the fundamental principles and building blocks of electrical and electronics engineering. The first three units cover the electric circuit laws, theorems, and principles of electrical machines. The last two units cover semiconductor devices and their applications.

Course Objectives:

- To impart the analysis and design aspects of DC networks in electrical and electronic circuits
- To explain the basic concepts of AC networks used in electrical and electronic circuits.
- To demonstrate the importance and operating principles of electrical machines (transformers, motors and generators)
- To impart the knowledge about the characteristics, working principles and applications of semiconductor diodes, Metal Oxide Semiconductor Field Effect Transistors (MOSFETs).
- To expose basic concepts and applications of Operational Amplifier and configurations.

Unit I: **7L**

DC Circuits: Basic circuit elements and sources, Ohms law, Kirchhoff's laws, series and parallel connection of circuit elements, Node voltage analysis, Mesh current analysis, Superposition, Thevenin's and maximum power transfer theorem.

Learning Outcomes

After completion of this unit the student will be able to

- state Ohms law and Kirchhoff's Laws (L1).
- calculate equivalent resistance of series and parallel connections in a circuit (L1).
- able to calculate voltage and current using voltage and current division methods (L2).
- determine the current, voltage and power in the given electrical circuit (L4).
- apply various theorems to analyze an electric circuit (L3).

Unit II: **8L**

AC Circuits: Alternating voltages and currents, AC values, single phase RL, RC, RLC series circuits, power in AC circuits, Power Factor, three phase systems-Star and Delta Connection-Three phase power measurement.

Learning Outcomes:

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

- describe AC voltages and currents (L1).
- analyse Series RL, RC and RLC circuits (L4).
- Learn calculations of power factor and power measurement (L2)
- Understand star and delta connections in three phase systems (L3).

Unit III: **9L**

Electrical Machines: Construction, working principle and application of DC machines, Transformers, single phase and three phase Induction motors, special machines-Stepper motor, Servo motor and BLDC motor.

Learning Outcomes:

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

- Understand working principle of dc machines (L1).
- demonstrate principle operation of transformer (L3).
- discuss about open and short- circuit tests of transformer (L2).
- explain the working principle of three phase induction motor (L5).
- gain knowledge on applications as special machines, stepper motor (L1).
- Identify and choose servo motor and BLDC motor applications (L2).

Unit IV: **8L**

Semiconductor Devices: p-n Junction diode - Basic operating principle, current-voltage characteristics, rectifier circuits (half-wave, full-wave, rectifier with filter capacitor), Zener diode as Voltage Regulator; Metal oxide semiconductor field effect transistor (MOSFET): Operation of NMOS and PMOS FETs, MOSFET as an amplifier and switch.

Learning Outcomes:

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

- describe the device structure and physical operation of a diode (L1).
- discuss V-I characteristics of diodes (L2).
- explain the use of diode as switch and in electronic circuits (L2).
- describe the construction and operation of n-channel and p-channel MOSFETs (L1).
- explain the use of MOSFET as an amplifier and bidirectional switch(L2).

Unit V: **8L**

Operational Amplifiers: The Ideal Op-amp, The Inverting Configuration, The closed loop gain, Effect of Finite open-loop gain, The Noninverting Configuration, The closed loop gain, Characteristics of Non-Inverting Configuration, Difference amplifiers, A Single Op-amp difference amplifier. Adders, subtractors, integrators, differentiators, filter circuits using Opamps,

Learning Outcomes:

After completion of this unit the student will be able to

- list the characteristics of an ideal Op Amp (L1).
- design the Inverting and Noninverting configurations of Op-Amp(L2).
- construct a single Op-amp difference amplifier (L3).
- List several applications of opamps

Basic Electrical and Electronics Engineering Laboratory

List of Experiments:

1. Verification of Kirchhoff's Laws.
2. Verification of DC Superposition Theorem.
3. Verification of Thevenin's Theorem.
4. Verification of Maximum power transfer Theorem.
5. Load test on DC generator.
6. Load test on single phase transformer.
7. Measurement of voltage, current and power factor of single phase RL, RC series circuits.
8. Measurement of voltage, current and power factor of single phase RLC series circuit.
9. Measurement of power in a three phase circuit.
10. Current Voltage Characteristics of a p-n Junction Diode/LED.
11. Diode Rectifier Circuits.

12. Voltage Regulation with Zener Diodes.
13. Design of a MOSTFET amplifier and MOSFET inverter/NOR gate
14. Inverting and Non-inverting Amplifier Design with Op-amps.
15. Simulation experiments using PSPICE

(a) Diode and Transistor Circuit Analysis.
(b) MOSFET Amplifier design.
(c) Inverting and Noninverting Amplifier Design with Op-amps.

Text Book(s):

1. D. P. Kothari, I. J. Nagrath, Basic Electrical and Electronics Engineering, 1/e, McGraw Hill Education (India) Private Limited, 2017.
2. B. L. Theraja, Fundamentals of Electrical Engineering and Electronics, 1/e, S. Chand Publishing, New Delhi, 2006.
3. Adel S. Sedra and Kenneth C. Smith, Microelectronic Circuits 6/e, Oxford University Press, 2014.

References:

1. S.K. Bhattacharya, Basic Electrical and Electronics Engineering, Pearson Education, 2011.
2. Dharma Raj Cheruku, B T Krishna, Electronic Devices and Circuits, 2/e, Pearson Education, 2008.
3. R. K. Rajput, Basic Electrical and Electronics Engineering, University Science Press, New Delhi, 2012.

Course Outcomes:

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

- predict and analyse the behaviour of an electrical circuit (L3).
- analyse the performance quantities such as losses, efficiency and identify applications of DC machines (L4).
- explain the use of transformers in transmission and distribution of electric power and other applications (L2).
- demonstrate the operation and applications of various electronic devices (L2).
- construct Inverting and Noninverting configurations of Op-amp (L3).

INTERNSHIP I

L T P C J
0 0 0 1 1

Prerequisite: Completion of minimum of four semesters

Course Objectives:
The course is designed to expose the students to expected industry skills and industry environment and to take up onsite assignment as trainees or interns.

Expected Course Outcome:

At the end of this internship the student should be able to:

1. Have an exposure to industrial practices and to work in teams
2. identify skill set required to participate activity in real-time projects relevant to the industry
3. Understand the impact of engineering solutions in a global, economic, environmental and societal context
4. formulate technical background required to participate in Internship 2

Contents: 1 **Week**

One week of work at industry site. Supervised by an expert at the industry.

Mode of Evaluation: Internship Report, Presentation and Project Review

INTERNSHIP II

L T P C J
0 0 0 1 3

Prerequisite: Completion of minimum of six semesters

Course Objectives:
The course is designed to expose the students to industry environment and to take up onsite assignment as trainees or interns.

Expected Course Outcome:

At the end of this internship the student should be able to:

1. Have an exposure to industrial practices and to work in teams
2. Communicate effectively
3. Understand the impact of engineering solutions in a global, economic, environmental and societal context
4. Develop the ability to engage in research and to involve in life-long learning
5. Comprehend contemporary issues
6. Engage in establishing his/her digital footprint

Contents: 1 **Week**

Four weeks of work at industry site. Supervised by an expert at the industry

Mode of Evaluation: Internship Report, Presentation and Project Review

COMPREHENSIVE EXAMINATION

L T P J C
1 0 0 0 1

Prerequisite: Completion of minimum of six semesters

Course Objectives:
1. Designed to test the students on the electronics and communication engineering concepts, and tools, and the process of identifying and solving engineering problems.

Course Outcomes
The students will be able to
1. Apply knowledge of mathematics, science, and engineering
2. Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health care and safety, manufacturability, and sustainability

Module:1 Networks, Signals and Systems
Network solution methods: nodal and mesh analysis; Network theorems: superposition, Thevenin and Norton‟s maximum power transfer; ye-Delta transformation; Steady state sinusoidal analysis using phasors; Time domain analysis of simple linear circuits; Solution of network equations using Laplace transform; Frequency domain analysis of RLC circuits; Linear 2-port network parameters: driving point and transfer functions; State equations for networks and Network Synthesis (RL,RC,LC and RLC Synthesis): Positive real functions, hurwitz polynomial, foster and cauer forms. Continuous-time signals: LTI System & Properties,Fourier series and Fourier transform representations, sampling and aliasing concepts and applications; Discrete-time signals: discrete time Fourier transform (DTFT), DFT, FFT, Z-transform. Interconnection of systems; Filter design concepts, phase and group delay concepts

Module:2 Electronic Devices and Circuits
Energy bands in intrinsic and extrinsic silicon; Carrier transport: diffusion current, drift current, mobility and resistivity; Generation and recombination of carriers; Poisson and continuity equations; P-N junction, Zener diode, BJT, LED, photo diode and solar cell; MOS Transistor Theory: nMOS, pMOS Enhancement Transistor, ideal I-V characteristics, MOS capacitor, C-V characteristics, DC transfer Characteristics of CMOS inverter.

Small signal equivalent circuits of diodes, BJTs and MOSFETs; Simple diode circuits: clipping, clamping and rectifiers; Special diodes, Single-stage BJT and MOSFET amplifiers: biasing, bias stability, mid-frequency small signal analysis and frequency response; BJT and MOSFET amplifiers: multi-stage, differential, feedback, tuned amplifiers, power and operational; Simple opamp circuits; Active filters; Sinusoidal oscillators: criterion for oscillation, single-transistor and op-amp configurations; Function generators, 555 timers, open and closed loop applications of Comparators, Voltage Regulators, regulator protection methods, noise analysis of electronic circuits, PLLs and Data converters

Module 3: Digital Circuits

Number systems; Combinatorial circuits: Boolean algebra, minimization of functions using Boolean identities and Karnaugh map, logic gates and their static CMOS implementations, arithmetic circuits, code converters, multiplexers, decoders and PLAs; Sequential circuits: latches and flip-flops, counters, shift- registers and finite state machines; Data converters: sample and hold circuits, ADCs and DACs; Semiconductor memories: ROM, SRAM, DRAM; 8-bit microcontroller (8051): architecture, programming, memory and I/O interfacing.

Module:4 Electromagnetics

Electrostatics; Maxwell‟s equations: differential and integral forms and their interpretation boundary conditions, wave equation, Poynting vector; Plane waves and properties: reflection and refraction, polarization, phase and group velocity, propagation through various media, skin depth; Transmission lines: equations, characteristic impedance, impedance matching, S-parameters, Smith chart; Waveguides: modes, boundary conditions, cut-off frequencies, Rader range equvation, Friss formula; Antennas: antenna types, radiation pattern, gain and directivity, return loss, antenna arrays; Wave Propagation, Antenna design considerations - Microstrip and Horn antennas. Basics of radar; Properties and characteristics of light sources (Laser and LED) and detectors; Light propagation in optical fibers.

Module 5: Control Systems

Basic control system components; Feedback principle; Transfer function; Block diagram representation; Signal flow graph; Transient and steady-state analysis of LTI systems; Frequency response; Routh-Hurwitz and Nyquist stability criteria; Bode and root-locus plots; Closed loop control system design by Nichols plot , PID controller design, Lag, lead and lag-lead compensation, States space models, states space equations and solutions, states space methods for controller designs and non-linear control systems and its applications.

Module 6: Communications

Random processes: autocorrelation and power spectral density, properties of white noise, filtering of random signals through LTI systems; Analog communications: amplitude modulation and demodulation, angle modulation and demodulation, spectra of AM and FM, superheterodyne receivers, circuits for analog communications; Information theory: entropy, mutual information and channel capacity theorem. Digital communications: PCM, DPCM, digital modulation schemes, amplitude, phase and frequency shift keying (ASK, PSK, FSK), QAM, MAP and ML decoding, matched filter receiver, calculation of bandwidth, SNR and BER for digital modulation; Fundamentals of error correction, Hamming codes; inter-symbol interference and its mitigation; Wireless Communication: Structure of a Wireless Communication Link, Modulation Techniques: QPSK, MSK, GMSK. Basics of TDMA, FDMA and CDMA.

Mode of Evaluation: 12 Quizzes with Multiple Choice Questions. Best 10 quizzes are considered for computing 100M. Student shall score atleast 80% in atleast 8 quizzes to be considered for grading

CAPSTONE PROJECT – INTRODUCTION

L	T	P	S	J	C
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Course Objectives:
To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field.

Course Outcome:
At the end of the course the student will be able to
1. Formulate specific problem statements for ill-defined real life problems with reasonable assumptions and constraints.
2. Perform literature search and / or patent search in the area of interest.
3. Conduct experiments / Design and Analysis / solution iterations and document the results.
4. Perform error analysis / benchmarking / costing
5. Synthesis the results and arrive at scientific conclusions / products / solution
6. Document the results in the form of technical report / presentation

Course Logistics
Capstone Project may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.

1. Project can be for one or two semesters based on the completion of required number of credits as per the academic regulations.
2. Can be individual work or a group project, with a maximum of 3 students.
3. In case of group projects, the individual project report of each student should specify the individual's contribution to the group project.
4. Carried out inside or outside the university, in any relevant industry or research institution.
5. Publications in the peer reviewed journals / International Conferences will be an added advantage

Mode of Evaluation: Periodic reviews, Presentation, Final oral viva, Poster submission

HSMCH102 - UNIVERSAL HUMAN VALUES 2: UNDERSTANDING HARMONY

L	T	P	C
2	1	0	3

Human Values Courses: During the Induction Program, students would get an initial exposure to human values through Universal Human Values – I. This exposure is to be augmented by this compulsory full semester foundation course.

OBJECTIVE: The objective of the course is four fold:
1. Development of a holistic perspective based on self- exploration about themselves (human being), family, society and nature/existence.
2. Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence
3. Strengthening of self-reflection.
4. Development of commitment and courage to act.

COURSE TOPICS: The course has 28 lectures and 14 practice sessions in 5 modules:

Module 1: Course Introduction - Need, Basic Guidelines, Content and Process for Value Education
1. Purpose and motivation for the course, recapitulation from Universal Human Values-I.
2. Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and Experiential Validation- as the process for self-exploration.
3. Continuous Happiness and Prosperity- A look at basic Human Aspirations
4. Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority.
5. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario
6. Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

Include practice sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking.

Module 2: Understanding Harmony in the Human Being - Harmony in Myself!
1. Understanding human being as a co-existence of the sentient 'I' and the material 'Body'.
2. Understanding the needs of Self ('I') and 'Body' - happiness and physical facility.
3. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer).
4. Understanding the characteristics and activities of 'I' and harmony in 'I'.
5. Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail.

6. Programs to ensure Sanyam and Health.

Include practice sessions to discuss the role others have played in making material goods available tome. Identifying from one's own life.

Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease

Module 3: Understanding Harmony in the Family and Society- Harmony in Human-Human Relationship

1. Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship
2. Understanding the meaning of Trust; Difference between intention and competence
3. Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship
4. Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals
5. Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

Include practice sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives.

Module 4: Understanding Harmony in the Nature and Existence - Whole existence as Coexistence

1. Understanding the harmony in the Nature
2. Interconnectedness and mutual fulfilment among the four orders of nature-recyclability and self-regulation in nature.
3. Understanding Existence as Co-existence of mutually interacting units in all-pervasive space.
4. Holistic perception of harmony at all levels of existence.
5. Include practice sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.

Module 5: Implications of the above Holistic Understanding of Harmony on Professional Ethics

1. Natural acceptance of human values
2. Definitiveness of Ethical Human Conduct
3. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order

4. Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above production systems.
5. Case studies of typical holistic technologies, management models and production systems
6. Strategy for transition from the present state to Universal Human Order:
   a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers
   b. At the level of society: as mutually enriching institutions and organizations
7. Sum up.

Include practice Exercises and Case Studies will be taken up in Practice (tutorial) Sessions e.g. To discuss the conduct as an engineer or scientist etc.

READINGS: Text Book

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010

Reference Books

1. Jeevan Vidya: EkParichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi.
5. Small is Beautiful - E. F Schumacher.
6. Slow is Beautiful - Cecile Andrews
7. Economy of Permanence - J C Kumarappa
8. Bharat Mein Angreji Raj - PanditSunderlal
9. Rediscovering India - by Dharampal
10. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
11. India Wins Freedom - Maulana Abdul Kalam Azad
12. Vivekananda - Romain Rolland (English)
13. Gandhi - Romain Rolland (English)

Lectures hours are to be used for interactive discussion, placing the proposals about the topics at hand and motivating students to reflect, explore and verify them. Tutorial hours are to be used for practice sessions.

While analysing and discussing the topic, the faculty mentor’s role is in pointing to essential elements to help in sorting them out from the surface elements. In other words, help the students explore the important or critical elements.

In the discussions, particularly during practice sessions (tutorials), the mentor encourages the student to connect with one's own self and do self- observation, self-reflection and self-exploration.

Scenarios may be used to initiate discussion. The student is encouraged to take up "ordinary" situations rather than" extra-ordinary" situations.

Such observations and their analyses are shared and discussed with other students and faculty mentor, in a group sitting.

Tutorials (experiments or practical) are important for the course. The difference is that the laboratory is everyday life, and practical are how you behave and work in real life. Depending on the nature of topics, worksheets, home assignment and/or activity are included. The practice sessions (tutorials)would also provide support to a student in performing actions commensurate to his/her beliefs. It is
intended that this would lead to development of commitment, namely behaving and working based on basic human values.

It is recommended that this content be placed before the student as it is, in the form of a basic foundation course, without including anything else or excluding any part of this content. Additional content may be offered in separate, higher courses.

This course is to be taught by faculty from every teaching department, including HSS faculty.

Teacher preparation with a minimum exposure to at least one 8- day FDP on Universal Human Values is deemed essential.

ASSESSMENT:
This is a compulsory credit course. The assessment is to provide a fair state of development of the student, so participation in classroom discussions, self-assessment, peer assessment etc. will be used in evaluation.

Example:
Assessment by faculty mentor: 10 marks
Self-assessment: 10 marks
Assessment by peers: 10 marks
Socially relevant project/Group Activities/Assignments: 20 marks Semester End Examination: 50 marks
The overall pass percentage is 40%. In case the student fails, he/she must repeat the course.

OUTCOME OF THE COURSE: By the end of the course, students are expected to become more aware of themselves, and their surroundings (family, society, nature); they would become more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.

They would have better critical ability. They would also become sensitive to their commitment towards what they have understood (human values, human relationship and human society). It is hoped that they would be able to apply what they have learnt to their own self in different day-to- day settings in real life, at least a beginning would be made in this direction.

This is only an introductory foundational input. It would be desirable to follow it up by

a) faculty-student or mentor-mentee programs throughout their time with the institution
b) Higher level courses on human values in every aspect of living. E.g. as a professional

PROJECT EXHIBITION I

L T P S J C
0 0 0 0 1 1

Course Objectives:
To provide platform for the student to exhibit their project work to

a) Excite interested students in continuing/initiating in the work of interest
b) Attract startups/industry to commercialize the project work
c) acquire comments on improving the quality of the work from other students/academicians/industry

Mode of Evaluation: Poster submission, Viva-Voce Examination

PROJECT EXHIBITION II

L T P S J C
0 0 0 0 1 1

Course Objectives:
To provide platform for the student to exhibit their project work to

a) Excite interested students in continuing/initiating in the work of interest
b) Attract startups/industry to commercialize the project work
c) acquire comments on improving the quality of the work from other students/academicians/industry

Mode of Evaluation: Poster submission, Viva-Voce Examination

BIOTECHNOLOGY WORKSHOP

This laboratory course provides hands on training to the students in basic experiments of engineering biotechnology. The student will be familiarised with the usage of scientific calculator, calibration of pH meter & rotameter, concepts of rate and mass transfer, retrieving biological data, growth and division of cells.

Course Objectives:

This workshop aims to

- provide fundamental concepts of microbiology, fermentation, bioinformatics, mass transfer and reaction engineering
- demonstrate bioreactor and flow cytometer
- understand and visualise different phases of mitosis

1. Applications of scientific calculator

   After completion of this experiment, the student will be able to use the calculator for all mathematical and scientific calculations.

2. Determination of rate constant of a reaction by integral method

   After completion of this experiment, the student will be able to determine the rate constant for any chemical or biochemical reaction

3. Measurement of oxygen diffused in water

   After completion of this experiment, the student will be able to measure the amount of oxygen present in water.

4. Mitosis cell division in onion root tips

   After completion of this experiment, the student will be able to observe mitotic cell division in onion root tips.

5. Estimation of sugar content by Brix meter

   After completion of this experiment, the student will be able to estimate the sugar content in any liquid sample.

6. Calibration of pH meter and pH measurement.

   After completion of this experiment, the student will be able to calibrate the pH meter for measuring pH of any given liquid sample.

7. Biological databases and information resources

   After completion of this experiment, the student will be able to retrieve the required data from biological databases and information resources.

8. Batch growth of yeast cells

   After completion of this experiment, the student will be able to prepare the media and grow the yeast cells in a conical flask.

9. Biological production of Wine

   After completion of this experiment, the student will be able to prepare wine using cells and raw materials.

10. Calibration of rotameter and measurement of flow rate.

    After completion of this experiment, the student will be able to calibrate rotameter for flow measurement.

11. Demonstration of bioreactor operation and its control

    After completion of this experiment, the student will be able to understand the operation and control of Bioreactor.

12. Demonstration of flow cytometry for animal cell counting

    After completion of this experiment, the student will be able to understand the principle of Flow cytometry and its usefulness in counting animal cells.

Course Outcomes:

The student will be able to:

- use the scientific calculator and microscope
- measure flow, pH, sugar content
- retrieve data
- observe cell division
- grow yeast cells
- produce and analyse wine
- explain the operation and control of bioreactors.

PROCESS CALCULATIONS

Large scale production in biotechnology industry involves a wide range of processes. This course introduces the concepts, laws and physico-chemical properties that are useful for bioprocess calculations. These calculations also enable the students to estimate the amount of chemicals required/heat released or absorbed in a bioprocess.

Course Objectives:

- To introduce the concepts of chemical calculations
- To provide the basis for chemical reactions
- To familiarize the concepts of material and energy balance
- To explain the material and energy balance calculations
- To expose the material and energy balance concepts to bioprocesses

Unit- I **Number of hours: 6**

Basic chemical calculations: Mole, atomic mass, molar mass, equivalent mass, stoichiometric and composition relationships for solids, liquids, solutions, gases: Weight percent, volume percent and mole percent, density and specific gravity, Behaviour of ideal gases, application of the ideal gas law, Dalton and Amagat laws of gaseous mixtures, Composition of gases on dry and wet basis.

Learning Outcomes:
After completion of this unit, the student will be able to

- apply ideal gas, Dalton and Amagats laws. (L3)
- estimate chemical masses, volumes and percentages. (L3)
- explain the relationship between reactants and products. (L2)
- apply ideal gas law. (L3)

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

Unit- II **Number of hours: 8**

Gases, Vapours and Liquids: Equations of state, Vapor pressure, effect of temperature on vapor pressure: Clausius-Clapeyron equation, Antoine equation. Reference substance vapor pressure plots: Cox chart and Duhring‟s plot, Vapor pressure of immiscible liquids, Ideal solutions and Raoult's law, non-volatile solutes, humidity, saturation, humid heat, humid volume, Dew point, humidity chart and its uses. Wet and dry bulb temperatures. Adiabatic vaporization and adiabatic saturation temperature.

Learning Outcomes:

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

- describe the factors affecting vapour pressure. (L2)
- explain the relationship between the temperature and vapour pressure. (L2)
- Outline the concept of adiabatic saturation and thermodynamic wet bulb temperature
- Interpret the humidity and dewpoint. (L2)
- predict the physico-chemical properties of air. (L2)

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

Unit- III **Number of hours: 8**

Material balances: Process flow sheet, Material balance without chemical reactions, Degrees of freedom, Tie element basis for calculations. Material balance calculations involving drying, dissolution and crystallization, continuous filtration, batch mixing, Recycling and bypassing operations, Material balance with chemical reactions, concept of excess reactant, limiting reactant, conversion, yield, degree of completion.

Learning Outcomes:

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

- explain process flow diagrams (L2)
- perform material balance for various unit operations. (L3)
- estimate product yield and reactant conversion. (L3)
- solve material balance for various unit processes with and without recycling. (L3)

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

Unit- IV **Number of hours: 10**

Energy balance: Components of energy balance equation, Concept of Enthalpy and heat capacity, Heat effects accompanying chemical reactions, standard heats of reaction, combustion and formation, Hess's law, effect of temperature on standard heats of reaction, steady state energy balance.

Learning Outcomes:

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

- identify various components of energy balance equation. (L1)
- interpret the heat effects in chemical reactions. (L2)
- predict the heat of combustion and heat of formation. (L3)
- explain the medical importance of gene disorders. (L2)
- apply Hess’s law for energy calculations. (L2)

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

Unit- V **Number of hours: 6**

Stoichiometry of microbial growth and product formation: Elemental balances, degree of reduction, yield coefficients, biomass yield, product stoichiometry, Theoretical oxygen demand, Maximum possible yield, Thermodynamics of microbial growth, Heat of reaction with oxygen as electron acceptor and without oxygen, Energy balance equations for fermentation and cell culture.

Learning Outcomes:

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

- outline the stoichiometry of microbial growth and product formation. (L2)
- explain the importance of oxygen in energy balance calculations.(L2)
- apply the material and energy balance concepts to fermentation and cell culture. (L2)

Pedagogy tools: Blended learning, Case let, video lectures, self-reading

Text Book(s):

1. Himmelblau, D. M., Riggs, J. B. "Basic Principles and Calculations in Chemical Engineering", 8/e., Pearson, 2015.
2. Bhatt, B. I., Vora, S. M., "Stoichiometry", 4/e Tata McGraw Hill, 2004.

Reference Book(s):

1. Felder, R. M.; Rousseau, R. W., "Elementary Principles of Chemical Processes", Third Edition, John Wiley & Sons, 2000
2. Hougen, O. A., Watson, K. M., Ragatz, R. A., "Chemical Process Principles, Part-I Material & Energy Balances", Second Edition, CBS Publishers & Distributors, 2004
3. Venkataramani, V., Anantharaman, N., Begum, K. M. Meera Sheriffa, "Process Calculations", Second Edition, Prentice Hall of India.
4. Sikdar, D. C., "Chemical Process Calculations", Prentice Hall of India.
5. Pauline M.Doran, Bioprocess Engineering Principles, 1/e, Academic Press, 2009.

	Program Objectives (POs)												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	1	1	2						1	1	2	1	1	
CO2		1	1	2	1		1				1	1	1	1	
CO3				1	3	1				1				2	2
CO4				1	3					1				2	1
CO5	1	1	2	2	3			1	1			2	1		

BIOCHEMISTRY

All living beings consist of assemblies of molecules. Few of these molecules serve as structural elements, others are responsible for production, storage, and transfer of energy, encoding and decoding of genetic information. This course introduces the structure, properties and function of molecules that are the constituents of biological systems. This course is prerequisite for molecular biology and biochemical engineering.

Course Objectives:

Introduce the biochemical basis of life from biomolecules.

- Impart knowledge of enzymes and kinetics
- Understanding how changes in structure affect function.
- Summarize structure and properties of biomolecules
- Explain the metabolic pathways with significance.
- Discuss the biological importance of lipids, proteins, nucleic acids, and hormones.

Pre-requisites
CHEM1001, BTEN1001, BTEN1021

Unit – 1: Introduction to Biochemistry, proteins, and enzymes

Introduction to Biochemistry: Organization of life, Chemical foundations of biology, non-covalent bonds
Amino acids and peptides: Structure and properties of amino acids, Classification of amino acids, peptide bond structure.
Proteins: Structure and classification of proteins, Structural organization of protein: primary structure of proteins, secondary structure of proteins – helix and pleated sheets, tertiary structure of protein. Structure and functions of hemoglobin.
Enzymes and Enzyme kinetics: Nomenclature, classification of enzymes, active site, factors affecting enzyme activity. Michaelis–Menten approach to enzyme kinetics, Mechanism of enzyme action. Nutritional aspects of proteins

Learning outcomes:

- explain organization of life and chemical bonds in biological system (L2)
- explain the structure and properties of amino acids (L2)
- outline the nomenclature and classification of enzymes (L1)
- analyze the structure of proteins with one example (L3)
- explain enzyme kinetics and mechanism of enzyme action (L2)

Pedagogy tools: Self reading, NPTEL, Practical, video, lecture, seminar, and blended learning

Unit-2: Carbohydrates

Classification, structure, and functions of monosaccharide (ribose, glucose, and galactose), disaccharides (Maltose, sucrose and lactose), polysaccharides (starch, cellulose and glycogen). Metabolic pathways: Glycogenesis and glycogenolysis, glycolysis and TCA cycle, HMP shunt pathway, gluconeogenesis, Electron transport chain and Oxidative phosphorylation.

Learning outcomes:

- outline the classification of structure of carbohydrates (L1)
- explain the structure and functions mono, di and polysaccharides(L2)
- explain metabolic pathways in synthesis and degradation of carbohydrates (L2)
- interpret the energy channeling to ATP through Electron transport chain (L3)

Pedagogy tools: Self reading, NPTEL, Practical, video, lecture, seminar, and blended learning

Unit-3: Lipids

Classification, structure and physiological functions of triglycerides, fatty acids, phospholipids, cerebrosides, gangliosides and cholesterol. Digestion and absorption of fats. Synthesis and degradation of fatty acids. Nutritional aspects fatty acids.

Learning outcomes:

- explain the structure and classification of lipids (L2)
- summarize the biological properties and functions of lipids (L2)
- explain the digestion, synthesis, and degradation of fatty acids (L2)

Pedagogy tools: Self reading, NPTEL, Practical, video, lecture, seminar, and blended learning

Unit-4: Nucleic acids

Structure of nucleic acids (DNA and RNA), structure and functions of purines, pyrimidines, nucleotides, Types of DNA and RNA. Biosynthesis and degradation of purine and pyrimidine nucleotides. Urea cycle.

Learning outcomes:

- explain the types of nucleic acids (L2)
- interpret the structure functions and conformation of nucleic acids (L2)
- explain the synthesis and degradation of purines and pyrimidines (L2)

Pedagogy tools: Self reading, NPTEL, Practical, video, lecture, seminar, and blended learning

Unit-5: Hormones and Nutritional Biochemistry

Inborn errors of metabolism (amino acids, carbohydrates, and nucleic acids), Classification of hormones and their functions. and fatty acids. Vitamins.

Learning outcomes:

- explain the genetic disorders of metabolic pathways (L2)
- summarize the hormones and their functions in human (L2)
- explain nutritional aspects of proteins and fatty acids (L2)

Pedagogy tools: Self reading, NPTEL, Practical, video, lecture, seminar, and blended learning

Course Outcomes:

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

- describe the structure and properties of common biomolecules (L1).
- describe standard metabolic pathways (L1).
- explain the functional properties of enzymes (L3)
- explain role of hormones in human body (L2).
- explain nutritional aspects of proteins and fatty acids (L2).

Text Books:

1. Donald Voet, Judith G. Voet, Charlotte W. Pratt **Voet's PRINCIPLES OF BIOCHEMISTRY** 5/e, John Wiley, 2018.

   Language: English, Country of origin: USA, ISBN-10: 1119451663

2. David L. Nelson and Michael M. Cox, Lehninger Principles of Biochemistry, 8/e, W. H. Freeman, 2021

Language: English, Country of origin: Germany, ISBN-10: 1319381499; ISBN-13 : 978-1319381493

3. U Satyanarayana, U. Chakrapani, Biochemistry, 5/e, Elsevier, 2020.

   Language: English, Country of Origin: India, ISBN-10: 8131262537; ISBN-13 : 978-8131262535

Reference Books:

1. Jeremy M. Berg, Lubert Stryer, John Tymoczko, and Gregory Gatto, Biochemistry 9/e, WH Freeman, 2019.

   Language: English, Country of Origin: India, SBN-10: 1319114652; ISBN-13: 978-1319114657

	POs												PSOs		
CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	3	3									1	
2	3	3	3	3	3									1	
3	3	3	3	3	3									1	
4	3	3	3	3	3									1	
5	3	3	3	3	3									3	1
Avg	3.0	3.0	3.0	3.0	3.0									1.4	1.0

1-Low, 2- Medium and 3- High Correlation

BIOCHEMISTRY LABORATORY

This laboratory course provides knowledge and hands on experience in qualitative and quantitative experiments of biochemistry to the students. The student will be able to learn preparation of buffers, identification and quantification of bio molecules, assay of enzymes, enzyme kinetics, and chromatography and electrophoresis techniques.

Course Objectives:

This laboratory aims to

Provide concepts in preparation of buffers, tests for identification of bio molecules, quantification methods, enzyme assay, and enzyme kinetic parameters. Understand the separation of bio molecules by various chromatography techniques; visualize bio molecules in electrophoresis techniques. Demonstrate absorption spectra of proteins and nucleic acids.

1. Preparation of buffers: Acetate, Phosphate and Citrate buffers
   After completion of this experiment, the student will be able to prepare different buffers and calibrate the pH meter.
2. Qualitative analysis of mono and disaccharides
   After completion of this experiment, the student will be able to identify mono and disaccharides with various qualitative tests
3. Qualitative analysis of amino acids
   After completion of this experiment, the student will be able to identify amino acids with various qualitative tests
4. Estimation of total carbohydrates by Anthrone method
   After completion of this experiment, the student will be able to measure the carbohydrate by colorimetric method
5. Estimation of proteins by Biuret method
   After completion of this experiment, the student will be able to measure the proteins by colorimetric method
6. Determination of Iodine value of lipids
   After completion of this experiment, the student will be able to determine iodine value of fats 7.
7. Assay of amylase and determination of kinetic parameters
   After completion of this experiment, the student will be able to assay enzyme and learn enzyme kinetics
8. Separation amino acids by paper chromatographic technique
   After completion of this experiment, the student will be able to separate amino acids by paper chromatography
9. Separation of sugars / amino acids by thin layer chromatographic technique
   After completion of this experiment, the student will be able to separate sugars / amino acids by thin layer chromatography
10. Separation of proteins by Gel filtration
    After completion of this experiment, the student will be able to separate proteins by gel filtration
11. Absorption spectra of proteins and nucleic acids
    After completion of this experiment, the student will be able to learn absorption spectra for proteins and nucleic acids
12. Demonstration of SDS-PAGE
    After completion of this experiment, the student will be able to understand principle of SDSPAGE and application of these techniques for identification of bio molecules.

Course Outcomes:

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

- prepare buffer solutions
- estimate carbohydrates, amino acids, proteins and lipids
- perform absorption spectra for biomolecules
- separate amino acids, sugars and proteins by chromatography

- separate proteins by electrophoresis

Text Books:

1. D.T. Plummer, Introduction to Practical Biochemistry, 3/e, Tata-McGraw Hill, 2002.
2. S. K. Sawhney and Randhir Singh, Introductory Practical Biochemistry, 2/e, Alpha Science International, 2005.

References

1. B. Shashidhar Rao and Vijay Deshpande, Experimental Biochemistry. I.K. International Publishing House, 2005.

Microbiology

Microbes are a diverse group of organisms that are too small to be seen by the human eye. Some microbes possess unique physiological and biochemical properties that can be utilized for industrial production. Other microbes are responsible for human, agricultural and veterinary diseases. This course describes the applications of microbiology in food, agriculture and environmental technology.

Course Objectives

1. Impart knowledge of history, salient developments and key contributors in microbiology.
2. Describe the morphological structure of Viruses, Yeast, Molds and Bacteria.
3. Explore the effect of various parameters on microbial growth.
4. Explain the role of microbes in industrial fermentation techniques.
5. Describe the microbial decontamination techniques.

Unit 1 Microbial World — No of Hours : 10

History, and important developments in Microbiology. Contributions of Nobel Laureates in Microbiology (Robert Koch, Emil, A.Von Behring, Ronald Ross and Barry Marshall). Microbial Taxonomy and diversity of Bacteria. Microbial Taxonomy and diversity of Archea. Molecular approaches to Microbial Taxonomy. Physiology and adaptation of extremophiles. Physiology and significance of Thermophiles, Psychropiles, Halophiles, and Methanogens.

Learning Outcomes

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

- Summarize the advancement of microbiological techniques over time (L1). L1
- Identify, group and classify the microorganism (L2). L2
- Understand the importance of extremophiles (L2) L2

Pedagogy tools:

Self-reading , Lecture

Unit 2 Morphology of Microbes — No of Hours : 9

Morphology of Viruses ; size, shape, symmetry, replication of viruses- lytic and lysogenic cycle. Bacteria: Ultra structure of Bacteria, cell wall, cell membrane, flagella, pili, capsule, endospore, and cell inclusions, differences between prokaryotic and eukaryotic cell. Bacterial growth kinetics. Yeasts and Molds: life cycle, economic importance of Yeast and Aspergillus.

Learning Outcomes

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

- Understand the cellular details of various groups of microorganism. L2
- Analyze and prepare the model for microbial growth kinetics. L3
- Differentiate between prokaryotic and eukaryotic organisms L3

Pedagogy tools:

Self-reading , Video , Lecture

Unit 3 Microbial nutrition No of Hours : 8

Nutrition requirements, nutritional types of bacteria, uptake of nutrients by cell. Microbial metabolism: Respiration, Photosynthesis and Nitrogen fixation.

Learning Outcomes

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

- Classify microbes on the basis of nutrition L2
- Understand the role of symbiotic bacteria L1
- Apply the knowledge of metabolisms in growth and perpetuation in bacteria L3

Pedagogy tools:

Self-reading , Lecture

Unit 4 Control of microorganisms and Applied Microbiology No of Hours : 10

Sterilization and Disinfection, effect of physical (moist and dry heat, radiation and filtration) and chemical agents. Antibiotics: classification, mode of action and resistance. Water, Food and Milk borne contamination and remedy. Basic microbial genetics - conjugation, transformation and transduction. Strain improvement of microbes of industrial importance.

Learning Outcomes

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

- Differentiate disinfection and sterilization (L2) L2
- Explain control of microbial infections in humans (L2) L2
- Apply the knowledge of microbial genetics for the development of novel strains (L3) L2

Pedagogy tools:

Self-reading , Lecture

Unit 5 Industrial Microbiology No of Hours : 8

Fermentation technology for production of alcohol, wine and beer. Role of microbes in bread making and bakery products, Production of enzymes (amylases and cellulases), Oil eating bacteria, Microbes in agriculture.

Learning Outcomes

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

- Illustrate the production of alcohol and fuel (L2) L2
- Apply microbial technologies for the production of fermented foods and enzymes(L3). L3
- Utilize microorganisms for bioremediation and yield improvement (L3). L3

Pedagogy tools:

Self-reading , Lecture

Texbook(s)	Topics

1. Reba Kanungo,'Ananthanarayan and Paniker's Textbook of Microbiology',11,Universities Press (India) Pvt. Ltd.,India,2020,978-9389211436	All Units
2. Pelczar, M. J. Jr., Chan, E. C. S. and Krieg, N. R.,'Microbiology: Application Based Approaches. ',10,Tata Mc Graw Hill Education,India,2009,978-0070151475	All Units
3. Madigan, M. T., Martinko, J. M., Bender, K. S., Buckley, D. H., Stahl, D. A. ,'Brock Biology Of Microorganisms, Microbiology ',14,Pearson Education,India,2017,978-9332586864	All Units

Additional Reading(s)	**Topics**
1. Alberts, et. al.,'The Molecular Biology of the Cell',6,W. W. Norton & Company,USA,2014,978-0815344322	Unit- II, III, IV
2. Gerard J. Tortora, Berdell R. Funke and Christine L. Case,'Microbiology: An Introduction',13,Pearson,India,2020,9780134605180	All Units
3. Joanne M Willey; Linda M Sherwood; Christopher J Woolverton; Lansing M Prescott; John P Harley; Donald A Klein,'Prescott, Harley, and Klein's Microbiology',7,New York : McGraw-Hill Higher Education,USA,2008,0071267271 9780071267274	All Units
4. Stanier RY, Ingraham JL, Wheelis ML, Painter P,,'General Microbiology ',5,Palgrave Macmillan,USA,1999,978-0333763643	All Units
5. Simon Baker, Carolone Griffiths and Jane Nicklin,'BIOS Instant Notes in Microbiology',4,Taylor & Francis,India,2012,978-0415607704	All Topics

Journal(s)	**Topics**
1. The Microbiological Society of Korea,'Journal of Microbiology',2021,1833	All Units
2. Martin G Klotz,'Frontiers in Microbiology',2021,1	All Units
3. Springer,'Nature Microbiology',2021,1	All Units

Website(s)	**Topics**
1. http:// https://www.edx.org/learn/microbiology,Dec. 8, 2021, 11:12 a.m.,http:// https://www.edx.org/learn/microbiology	All Unita
2. https://openstax.org/details/books/microbiology,Dec. 8, 2021, 11:12 a.m.,https://openstax.org/details/books/microbiology	All Units
3. https://openstax.org/details/books/microbiology,Dec. 8, 2021, 11:12 a.m.,https://openstax.org/details/books/microbiology	All Units
4. https://www.coursera.org/courses?query=microbiology,Dec. 8, 2021, 11:12 a.m.,https://www.coursera.org/courses?query=microbiology	All Units
5. https://www.coursera.org/learn/antimicrobial-resistance,Dec. 8, 2021, 11:12 a.m.,https://www.coursera.org/learn/antimicrobial-resistance	Unit - IV

Practical Experiment

Topic	Type
Preparation of nutrient broth, nutrient agar and inoculation of bacteria.	Experiment
Isolation of pure cultures.	Experiment
Staining of microbes- simple staining, Gram staining, negative staining, capsule staining and spore staining.	Experiment
Motility of microbes.	Experiment
Motility of microbes.	Experiment
Morphology of fungi (Aspergillus niger)	Experiment
Morphology of yeast (Saccharomyces cerivisiae)	Experiment
Biochemical tests - IMViC test, Amylase test, Hydrogen Sulphide production test.	Experiment
Testing of microbiological quality of milk.	Experiment
Testing of microbiological quality of water.	Experiment
Microbial assay of antibiotics.	Experiment
Evaluation of disinfectant.	Exercise
Production of alcohol.	Project

	POs												PSOs		
CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	1	2	1	1	1	2	1	1	1	1	2	3	1	1
2	3	1	3	3	2	1	3	1	1	1	1	2	3	2	2
3	3	1	1	2	3	1	3	1	2	1	2	2	3	3	3
4	3	2	2	3	3	1	3	1	2	1	1	2	3	3	3
5	3	3	3	3	3	1	3	1	2	1	2	1	3	3	3
Avg	3.0	1.6	2.2	2.4	2.4	1.0	2.8	1.0	1.6	1.0	1.4	1.8	3.0	2.4	2.4

1-Low, 2- Medium and 3- High Correlation

Course Outcomes(COs)

1 Isolate and identify the microorganisms.
2 Analyze and apply the microbial metabolism for process or strain improvement
3 Define, describe and utilize microbial growth in fermentation and biological process.
4 Perform sterilization techniques.
5 Assess the quality of milk, water and biological samples.

Instrumental Methods of Analysis

Instrumental methods of analysis are extensions of the human senses for perceiving the world. Some of these methods enable us to observe the organization of biological systems at a much higher level of resolution than the human eye, whereas others provide information for which there is no human equivalent sense, such as information regarding identity, purity and composition. The objective of this course is to describe the principles of instrumental methods for quantitative and qualitative analysis in biotechnology with examples related to quality control, process monitoring, biomolecular system characterization and diagnostic applications.

Course Objectives

- Summarize methods for quantitative and qualitative analysis of biomolecules and biomolecular systems (L2)
- Compare methods for determination of molecular mass and particle size distribution (L4)
- Explain the principles of the methods for determination of molecular structure (L2)
- List methods for studies of biomolecular interactions (L1)
- Identify methods for high throughput analysis (L3)

Unit 1 Separation methods — No of Hours : 5

Principles of Centrifugation, Analytical Centrifugation. Preparative centrifugation. Principles of Chromatography. Types of Chromatography. Principles of Electrophoresis, Gel Electrophoresis.

Learning Outcomes

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

- Calculate molecular mass from sedimentation data — L3
- Select of optimum chromatographic method for separation — L2
- Explain the principles of electrophoresis — L1

Pedagogy tools:

Self-reading , Lecture

Unit 2 Optical Methods — No of Hours : 7

UV-Visible spectroscopy. Vibrational spectroscopy. Fluorescence spectroscopy. Refractometry, Polarimetry and Circular Dichroism. Microscopy: Confocal light microscopy. Cryo-electron microscopy. Determination of particle number and particle size from light scattering data. Structure determination of biomolecules and biomolecular assemblies from X-ray diffraction data.

Learning Outcomes

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

- Predict relation between structure and spectrum — L3
- Estimate concentrations from absorbance data — L3
- Calculate molecular mass from scattering data — L3

Pedagogy tools:

Self-reading , Lecture

Unit 3 Mass spectrometry — No of Hours : 5

Principles and components of mass spectrometers. Ionization methods. Determination of empirical formula. Determination of structure of small organic molecules. Oligonucleotide sequencing. Peptide and protein sequencing. Mass spectroscopy for Metabolomics and Proteomics.

Learning Outcomes

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

- Identify optimum method of ionization for given analyte L3
- Calculate empirical formula from mass spectral data L3
- Calculate molecular mass of a protein from Electrospray Ionization data L3

Pedagogy tools:

Self-reading , Lecture

Unit 4 NMR spectroscopy No of Hours : 6

Principles of Magnetic Resonance. Principles and components of Fourier Transform NMR spectrometer. Chemical shift, coupling constants and peak areas. Structure determination of small organic compounds using NMR spectroscopic data. Multidimensional NMR spectroscopy. Application of solution NMR spectroscopy for protein structure determination. NMR spectral fingerprinting. Principles of MRI.

Learning Outcomes

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

- Summarize the principles of FT NMR spectroscopy L2
- Apply NMR spectroscopic data for structure determination of small organic molecules L3
- List multidimensional NMR spectroscopic methods for biomolecular structure determination L1

Pedagogy tools:

Self-reading , Lecture

Unit 5 MicroAnalytical Methods No of Hours : 7

Principles, applications and types of Biosensors. Glucose Biosensors. Principles and applications of Microarrays. Microarray fabrication. Detectors for microarrays. Introduction to Micro Electro Mechanical systems. Fabrication of MEMS. Principles and applications of Microfluidic systems. Lab-on-a-chip devices exemplified with PCR-chips. Point of care devices for diagnostic applications.

Learning Outcomes

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

- Explain the principles and applications of Biosensors L1
- Explain the principles and applications of BioMicrofluidics L1
- Explain the power of high throughput workflow in biotechnology L1

Pedagogy tools:

Self-reading , Lecture

Texbook(s)

1. Robert M. Silverstein, Francis X. Webster, David J. Kiemle, David L. Bryce,'Spectrometric Identification of Organic Compounds. ',8th Edition,Wiley,USA,2015,9788126556595,Unit-2

2. Andreas Manz, Petra S Dittrich, Nicole Pamme, Dimitri Iossifidis,'Bioanalytical Chemistry ',2nd Edition, World Scientific.,USA,2015,1783266724,Units:1-4

Additional Reading(s)

1. David A. Wells. ,'High Throughput Bioanalytical Sample Preparation: Methods and Automation Strategies. 2nd ed. ',2nd Edition,Elsevier,Europe,2020,1,Unit-5

2. Xiujun James Li, Yu Zhou,'Microfluidic Devices for Biomedical Applications.',2nd Edition,Woodhead Publishing. Elsevier,Europe,2021,0128199717,Unit-5

3. Jaime Castillo-León, Winnie E. Svendsen,'Lab-on-a-Chip Devices and Micro-Total Analysis Systems: A Practical Guide ',1st Edition,. Springer,USA,2014,9783319086866,Unit-5

Journal(s)

1. Rienzo et al.,,'Lab on a Chip: High-throughput optofluidic screening for improved microbial cell factories via real-time micron-scale productivity monitoring',2021,2901,Unit-5

Course Outcomes:

1 Compare methods for determination of mass and particle size (L2)
2 Explain the principles of optical methods for characterization of biomaterials (L1)
3 Determine the sequence of proteins from mass spectrometry data (L5)
4 Analyze data from NMR spectroscopy (L4)
5 List the applications of high-throughput and miniaturized devices in biotechnology (L1)

	POs												PSOs		
CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	3	3									1	
2	3	3	3	3	3									1	
3	3	3	3	3	3									1	
4	3	3	3	3	3									1	
5	3	3	3	3	3									3	1
Avg	3.0	3.0	3.0	3.0	3.0									1.4	1.0

1-Low, 2- Medium and 3- High Correlation

Genetics & Molecular Biology

Genetics explains the transmission of characters from one generation to the next generation. Molecular biology explains the molecular basis for the transmission of this information. In addition, molecular biology also describes how genetic information is decoded by cellular machines made of molecular assemblies and how this information is utilized in biological systems. This course is prerequisite for genetic engineering.

Course Objectives

• Describe the principles of genetics in inheritance of character
• Provide knowledge in prokaryotic, eukaryotic cells and their organelles
• Describe Gene structure, function, cell cycle and signaling
• Describe DNA replication, gene expression and regulation at different levels
• Introduce the molecular basis of Mutations, DNA repair and genomics.

Unit 1 Principles of Inheritance — No of Hours : 9

Principles of Inheritance: Mendelian and non-Mendelian inheritance. Linkage and crossing over, mapping of genes. Cytoplasmic inheritance. Hardy-Weinberg equilibrium.

Learning Outcomes

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

- Explain the segregation of chromosomes during meiosis (L2) 2
- Relate inheritance patterns and position on chromosomes. (L2) 2
- correlate the frequency of recombinant gametes with the frequency of crossing-over. (L3) 2
- Mapping of genes based on linkage groups (L3) 3
- understand the molecular basis of mutations and repair (L2) 2

Pedagogy tools:

Self-reading , Video , Blended Learning , Caselet , NPTEL

Unit 2 Cell biology and cell cycle — No of Hours : 8

Structure of cell membrane, cellular organelles and their structure and functions. Organization of the chromosome, euchromatin and heterochromatin. Cell division. Cell cycle and its regulation: CDC mutants, protein kinases, cyclins.

Learning Outcomes

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

- Explain the importance of cell membrane and cell organelles (L2) 2
- distinguish the level of organization in prokaryotes and eukaryotes (L4) 2
- demonstrate the stages of cell cycle and its importance (L2) 3
- understand meiosis (L2) 2

Pedagogy tools:

Self-reading , Video , Blended Learning , Caselet , NPTEL

Unit 3 DNA structure and Replication No of Hours : 10

DNA structure and topology. Enzymology and mechanism of replication in prokaryotes and eukaryotes. Models of replication. Transposons. Molecular mechanism of recombination. Molecular basis of mutations, DNA repair mechanisms. Molecular mechanisms for epigenetics.

Learning Outcomes

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

- explain DNA structure and its topological constraints (L2) 1
- explain the mechanism of replication in prokaryotes and eukaryotes (L2) 2
- summarize models of replication (L2) 2
- understand role of transposons in genetic recombination (L2) 2

Pedagogy tools:

Self-reading , Video , Blended Learning , Caselet , NPTEL

Unit 4 Principles of transcription and regulation of gene expression

No of Hours : 9

Principles of transcription: Structure and function of prokaryotic RNA polymerase, mechanism of transcription in prokaryotes and eukaryotes, post transcriptional processing. Operon concept, regulation of gene expression in E.coli. Biochemical control of gene expression in eukaryotes.

Learning Outcomes

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

- describe the role of protein-DNA interactions in regulating transcription initiation (L2) 2
- Discuss the mechanism of transcription (L2) 2
- describe the process and significance of RNA processing in eukaryotes (L2) 2
- identify the similarities and differences in gene regulation in prokaryotes and eukaryotes (L3) 3

Pedagogy tools:

Self-reading , Video , Blended Learning , Caselet , NPTEL

Unit 5 General features of genetic code and protein targeting and processing

No of Hours : 9

General features of genetic code, structure and function of translation machinery in prokaryotic and eukaryotic systems, protein targeting and processing. Signal sequences, signal receptor protein and signal hypothesis.

Learning Outcomes

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

- outline the features of genetic code 2
- understand its significance in central dogma (L2) 3
- describe the mechanism of protein synthesis (L2) 2
- explain the mechanisms of Protein targeting and processing (L2) 2

Pedagogy tools:

Self-reading , Video , Blended Learning , Caselet , NPTEL

Texbook(s)

1. J. D. Watson, T. A. Baker, S. P. Bell, A. Gann, M. Levine and R. Losick,'Molecular Biology of the Gene',7,Pearson,USA,2014,978-0-321-76243-6,Unit-3, 4, 5

2. Robert Brooker,'Genetics: Analysis and Principles',6,McGraw-Hill,USA,2017,1259921654,Unit-1

Additional Reading(s)

1. B. Alberts, A. Johnson, J. Lewis, D. Morgan, M. Raff, K. Roberts and P. Walter, ,'Molecular Biology of the Cell',6,Garland Publishers,United states,2014,978-0815345244,Unit-2, 3

2. EDP De Robertis,'Cell and Molecular Biology',8,Lippincott, Williams and Wilkins,United states,2011,0781734932,Unit-2, 3,4,5

3. Harvey Lodish, Arnold Berk, Chris Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Kelsey Martin, Michael Yaffe, Angelika Amon ,'Molecular Cell Biology',9,W.H.Freeman,USA,2021,1319365485,Unit-2,3,4,5

Journal(s)

Website(s)

	POs												PSOs		
CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2											1	3		
2	3	2		3								1	3	2	2
3	3												3	2	
4	3											1	3		
5	3												3		
Avg	2.8	2.0		3.0								1.0	3.0	2.0	2.0

1-Low, 2- Medium and 3- High Correlation

Course Outcomes(COs)

1	explain the concepts of gene structure and its function (L2)
2	summarize the inheritance of characters by mendelian and non-mendelian genetics (L2)
3	explain the molecular basis of mutations and DNA repair (L2)
4	explain the mechanism of gene regulation (L2)
5	summarize the importance of genetic code and central dogma (L2)

FLUID MECHANICS AND MECHANICAL OPERATIONS

Fluid mechanics explains the relationships between force, pressure and fluid movement. Fluid mechanics can be used to understand the flow of fluids in pipes and mixing in bioreactors. Mechanical operations are applied in down-stream processing. This course introduces the principles of fluid mechanics and mechanical operations that are relevant for industrial biotechnology. The instruments used for measurement and control of fluid flow are also described.

Course Objectives:

- explain basic concepts of fluid flow
- Describe the devices for measurement of fluid flow
- Discuss the application of fluid mechanics to bioprocess industries
- Explain principles of mechanical operations
- Discuss construction and working of equipment for mechanical operations.

Unit- I	**10 hrs**

Units and dimensions, types of fluids, hydrostatic pressure, pressure distribution in static fluids, pressure measuring devices, introduction to fluids in motion, concept of stream lines, stream tubes, viscosity, rheological properties of fluids.

Learning Outcomes:

At the end of this unit, the student will be able to

- Outline the basic principles of fluid mechanics (L1)
- Describe fluid Mechanics from a rational and fundamental point of view. (L2)
- Analyze pipe flow and fluid machinery. (Lf4)
- Examine the properties of equations of motion in fluids (L2)
- Describe the properties of non-Newtonian flow. (L2)

Unit- II	**10 hrs**

Boundary layer formation and growth in tubes and on plates, Boundary layer separation and wake formation; Basic equations of fluid flow: continuity equation, and mechanical energy equation (Bernoulli equation).

Learning Outcomes:

At the end of this unit, the student will be able to

- Analyze fluid flow problems with the application of the momentum and energy equations (L4)
- Understand fluid particle systems and equipment (L2)
- Derive the conservation equations for flow of fluids (L2)

Unit- III	**9 hrs**

Flow of incompressible fluids in pipes: relation between skin friction and wall shear, laminar flow in pipes: Hagen-Poiseulle equation, friction factor, friction from changes in velocity or direction. Drag, drag coefficient, flow through beds of solids, fluidization, mechanism of fluidization, applications of fluidization.	
Learning Outcomes:	
	After completing this unit, the student will be able to • Understand fluid flow through packed and fluidized bed (L2) • Outline an approach for solving Fluid Mechanical problems.(L2) • Explain the role of friction in fluid flow (L2) • Understand fluidization techniques (L2)
Unit- IV	**8 hrs**
Transportation and metering of fluids: reciprocating, rotary, peristaltic and centrifugal pumps; flow measuring devices: venturi meter, orifice meter, rotameter, and pitot tube. Mechanical Separations: Screening, differential and cumulative screen analysis, capacity and effectiveness of screens; screening equipment: grizzly, gyratory and vibratory screens.	
Learning Outcomes:	
	After completing this unit, the student will be able to • Identify suitable devices for flow measurement (L2) • Use of pumps for fluid transportation (L2) • Definition of particle and powder characteristics (L2) • Select optimum solid-solid separation method (L2) • Perform basic design calculations for screening operations (L2)
Unit- V	**8 hrs**
Characteristics of solid particles, principles of comminution: laws of crushing (Rittinger's, Bond's, Kick's laws); description and working of size reduction equipment: jaw, gyratory crusher, roll crushers, ball mill, hammer mill, and fluid energy mill.	
Learning Outcomes:	
	After completing this unit, the student will be able to • Discuss the mechanical properties of particles (L2) • Select suitable size reduction equipment (L5) • Identify microscopic mechanisms involved in particle processing (L2)
Course Outcomes:	
	After the completion of the course the student should be able to • Identify the types of non-Newtonian fluids (L2) • Characterize and describe fluid-particle systems in terms of their basic physical properties. (L2)

	• Impart the f concepts of fluid statics, pressure distribution and dimensional analysis(L2) • Learn basic principles of particle preparation and their characterization (L2) • Study and understand the principles of various size reduction (L4) • Perform basic design calculations and analyses of typical fluid-particle operations. (L4)
Text Books:	
	1. W.L. McCabe, J.C. Smith, and P. Harriot, Unit Operations of Chemical Engineering, 7/e, McGraw-Hill International Edition, 2017.
References:	
	1. J.M. Coulson, and J.F. Richardson, Chemical Engineering-Volume One, 6/e, The English Language Book Society and Permagon Press, 1999. 2. G.G. Brown, Unit Operations, CBS Publishers, 2005.

FLUID MECHANICS AND MECHANICAL OPERATIONS LABORATORY

List of experiments	
	1. Calibration of Rotameter. 2. Determination of orifice coefficient. 3. Determination of venturi coefficient. 4. Verification of Bernoulli's equation. 5. Friction losses in fluid flow in pipes 6. Determination of pressure drops in a packed bed for different fluid velocities. 7. Determination of pressure drop and void fraction in a fluidized bed. 8. Determination of centrifugal pump efficiency 9. Sampling of materials (Riffle sampling and cone quartering sampling). 10. Determination of energy consumption in size reduction using roll crusher. 11. Determination of energy consumption in size reduction using ball mill. 12. Determination of effectiveness of a given screen.
References:	
	1. B. Majumdar, Fluid Mechanics with Laboratory Manual, PHI, 2013. 2. V.P. Gupta, K. Chandra, and K.S. Gupta, Laboratory Manual of Fluid Mechanics and Machines, CBS, 2009.

	POs												PSOs		
CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	3	3									1	
2	3	3	3	3	3									1	
3	3	3	3	3	3									1	
4	3	3	3	3	3									1	
5	3	3	3	3	3									3	1
Avg	3.0	3.0	3.0	3.0	3.0									1.4	1.0

1-Low, 2- Medium and 3- High Correlation

BIOCHEMICAL THERMODYNAMICS

Thermodynamics is useful to understand the factors that affect the stability of a system at equilibrium. This course explains the fundamental laws of thermodynamics and introduces the concepts necessary to predict the feasibility of a process. These concepts are applied to explain conformational equilibria of biomolecules and energy storage & utilization in biological systems.

Course Objectives:

- Explain thermodynamic properties and laws
- Estimate free energies of various biochemical reactions
- Derive fundamental property relations using state variables
- Explain phase equilibrium and chemical reaction equilibrium
- Apply laws of thermodynamics to biological systems

Unit- I	**10 hrs**

Zeroth law of thermodynamics, The first law of thermodynamics and other basic concepts: Joule's experiments, internal energy, the first law of thermodynamics, energy balance for closed systems, thermodynamic state and state functions, equilibrium, the phase rule, the reversible process, constant volume and constant pressure processes, enthalpy, heat capacity.

Learning Outcomes:

At the end of this unit, the student will be able to

- understand the importance of thermodynamics in biotechnology. (L1)
- determine the energy requirement of a process (L3)
- explain thermodynamic properties and thermodynamic laws (L1)

Unit- II	**10 hrs**

The second law of thermodynamics: Statement of the second law, heat engines, thermodynamic temperature scales, entropy, entropy changes of an ideal gas, mathematical statement of the second law. The third law of thermodynamics.

Learning Outcomes:

At the end of this unit, the student will be able to

- understand the importance of thermodynamic temperature scales. (L1)
- understand entropy and its changes. (L1)
- estimate the entropy change associated with a process (L3)

Unit- III	**9 hrs**

Thermodynamic properties: PVT behavior of pure substances, thermodynamic property relations for homogeneous phases. Solution thermodynamics: fundamental property relation, chemical potential and phase equilibria, fugacity and fugacity coefficient.

Learning Outcomes:

	After completing this unit, the student will be able to • understand various ways of presenting thermodynamics data. (L1) • determine the thermodynamic properties from available data. (L3) • relate thermodynamic properties from other properties. (L2) • understand the concepts of fugacity. (L1) • understand phase equilibria. (L1)
Unit- IV	**8 hrs**
Chemical reaction equilibria: The reaction coordinate, application of equilibrium criteria to chemical reactions, the standard Gibbs energy change and the equilibrium constant, effect of temperature on the equilibrium constant, relation of equilibrium constants to composition, phase rule and Duhem's theorem for reacting systems.	
Learning Outcomes:	
	After completing this unit, the student will be able to • explain Chemical reaction equilibria. (L1) • understand the importance of Gibbs energy. (L1) • determine the effect of physical parameters on chemical reactions. (L3)
Unit- V	**8 hrs**
Biochemical applications of thermodynamics: Factors affecting stability of double stranded DNA, statistical thermodynamics of monomer-dimer equilibrium for DNA. The helix-coil transition in polypeptides, ligand-receptor binding equilibria. ATP-ADP energy storage and utilization.	
Learning Outcomes:	
	After completing this unit, the student will be able to • explain importance of thermodynamics in biology. (L1) • understand the reasons for stability of DNA. (L1) • interpret ligand receptor binding equilibrium data. (L2)
Course Outcomes:	
	After the completion of the course the student should be able to • apply the fundamental concepts of thermodynamics to engineering applications (L3) • estimate thermodynamic properties of substances in gas and liquid states. (L3) • determine thermodynamic efficiency of a process. (L3) • Analyze chemical reaction equilibrium data (L3) • Comprehend the thermodynamic basis of biological phenomena (L2)
Text Books:	
	1. JM. Smith, HC Van Ness, MM Abbott, Chemical Engineering Thermodynamics, 6/e, Tata McGra-Hill Edition, 2008.

	2. I Tinoco, K Sauer, J C Wang, J D Puglisi, G. Harbison and D Rovnyak, Physical Chemistry: Principles and Applications in Biological Sciences, Pearson, 2013.
References:	
	1. S.I. Sandler, Chemical, Biochemical and Engineering Thermodynamics, 5/e, Wiley, 2017. 2. K. Dill and S Bromberg, Molecular driving forces: statistical thermodynamics in biology, chemistry, physics and nanoscience, 2/e Garland science, 2012 3. J.M. Smith, H.C. van Ness, and M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, 6/e, McGraw-Hill, 2003.

	POs												**PSOs**		
CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	3	3									1	
2	3	3	3	3	3									1	
3	3	3	3	3	3									1	
4	3	3	3	3	3									1	
5	3	3	3	3	3									3	1
Avg	3.0	3.0	3.0	3.0	3.0									1.4	1.0

1-Low, 2- Medium and 3- High Correlation

BIOCHEMICAL REACTION ENGINEERING

All biochemical reactions occur at finite rates. Estimation of the time required for a process to yield the required amount of product is essential for design of any process. Product yield is a function of the reaction conditions as well as the type of reactor. Models of ideal reactors provide quantitative information regarding yield and process efficiency. This course is an introduction to the models of reactors.

Course Objectives:

- Describe kinetics of homogeneous and heterogeneous reactions
- Explore the design of batch reactors and homogeneous flow reactors
- Introduce the techniques used for designing non isothermal reactors.
- Introduce different models to interpret non ideal flow in reactors

Unit- I	**8 hrs**

Kinetics: Kinetics of homogeneous reactions, elementary and non elementary reactions; collision theory and transition state theory, Arrhenius' relation, Monod kinetics. Kinetics of heterogeneous reactions: immobilized enzyme kinetics, effects of mass transfer on immobilized enzyme kinetics.

Learning Outcomes:

At the end of this unit, the student will be able to

- Explain kinetics of homogeneous and heterogeneous reactions (L_2)
- Analyze the temperature dependency of the rate equation (L_2)
- Analyze effect of mass transfer on enzyme kinetics. (L_2)

Unit- II	**8 hrs**

Introduction to types of reactors and bioreactors, analysis of batch reactor data, isothermal batch reactor design, batch reactor design for autocatalytic reactions, Design of fermenter, Design of enzyme reactor

Learning Outcomes:

At the end of this unit, the student will be able to

- Demonstrate design of an ideal batch reactor. (L2)
- Interpret batch reactor data (L_2)
- Explain design of a fermenter (L2)

Unit- III	**8 hrs**

Homogeneous flow reactors: Design equation for plug flow reactor (PFR) and continuous stirred tank reactor (CSTR), design of PFR and CSTR for single reactions. Cascade of CSTRs and combination of PFR and CSTR Design for autocatalytic reactions, Stirred tank fermenter, multiple fermenters connected in series

Learning Outcomes:

After completing this unit, the student will be able to

- Demonstrate design of an ideal flow reactor (L2)

	• Identify best system for a given conversion. (L3) • Selection of best arrangement of a set of ideal reactors (L_3) • Compare single and multiple ideal reactor systems (L_5)

Unit- IV	**8 hrs**

Non-isothermal design: Energy balance equations for batch, PFR and CSTR under non-isothermal conditions. Equilibrium conversion under adiabatic conditions. Design of the homogeneous reactors under adiabatic conditions. Sterilization kinetics, Batch & Continuous sterilization

Learning Outcomes:

	After completing this unit, the student will be able to • design reactors for non isothermal conditions (L6) • relate temperature and conversion or reaction rate for reactors (L_2) • design reactors on basis of energy balance (L6) • explain sterilization techniques (L_2)

Unit- V	**8 hrs**

Non-ideal flow: Residence time distribution curves E, F and C; interpretation of the response data for the dispersion and tanks -in-series models (omit multi parameter models).

Learning Outcomes:

	After completing this unit, the student will be able to • apply the tracer concentration time data (L3) • calculate distribution functions, mean residence time, and variance (L3) • quantify non-ideal flow from experimental data (L_3)

Course Outcomes:

	After the completion of the course the student should be able to • design of batch reactor using rate law and its parameters (L6) • design of flow reactors and fermentors (L_6) • select reactor and conditions to minimize unwanted products (L_3) • design of reactors on the basis of energy balance. (L_6) • identify problems in real reactors (L_3)

Text Books:

	1. Octave Levenspiel, Chemical Reaction Engineering, 3/e, John Wiley, 2010. 2. J.M. Smith, Chemical Engineering Kinetics, 3/e, McGraw Hill, 1981.

References:

	J.M. Coulson, and J.F. Richardson, Chemical Engineering-Volume One, 6/e, The English Language Book Society and Permagon Press, 1999. 2. G.G. Brown, Unit Operations, CBS Publishers, 2005.

BIOCHEMICAL REACTION ENGINEERING LAB

This laboratory course will reinforce the students' understanding of basic concepts pertaining to analyze kinetics for complex reactions using differential and integral methods. Batch reactor will be employed to analyze rate kinetics for isothermal and exothermic reactions. The tracer dynamics in reactors will be studied using Residence Time Distribution. The analysiswill include various experiments with the objective of sample preparation, measurement of concentration, prediction of kinetics and modeling of kinetics data.

List of Experiments:

1. Determination of the order of a reaction using a batch reactor and analysing the data by a) differential method and b) integral method.

[After completing this experiment the student will be able to analyze data to determine the rate law and rate law parameters using graphical and numerical techniques]

2. Determination of the activation energy of a reaction using a batch reactor.

[After completing this experiment the student will be able to Analyze the temperature dependency of the rate equation.]

3. To determine the specific reaction rate constant of a reaction of known order using a batch reactor

[After completing this experiment the student will be able to analyze data to determine the rate law and rate law parameters using graphical and numerical techniques]

4. To determine the order of the reaction and the rate constant using a tubular reactor.

[After completing this experiment the student will be able to analyze data of plug flow reactor to determine the rate law and rate law parameters using graphical and numerical techniques]

5. To determine the order of the reaction and the rate constant using a CSTR

[After completing this experiment the student will be able to analyze data of CSTR to determine the rate law and rate law parameters using graphical and numerical techniques]

6. Determination of RTD and dispersion number in a tubular reactor using a tracer..

[After completing this experiment the student will be able to apply the tracer concentration time data of plug flow reactor to calculate the external age distribution function., the cumulative distribution function, the mean residence time, and the variance]

7. Axial mixing in a packed bed. Determination of RTD and the dispersion number for a packed-bed using tracer.

[After completing this experiment the student will be able to apply the tracer concentration time data of packed bed to calculate the external age distribution

	function., the cumulative distribution function, the mean residence time, and the variance] 8. Determination of RTD and dispersion number in CSTR [After completing this experiment the student will be able to apply the tracer concentration time data of CSTR to calculate the external age distribution function., the cumulative distribution function, the mean residence time, and the variance] 9.Performance of reactors in series: i. plug-flow reactor followed by a CSTR ii . CSTR followed by Plug flow reactor [After completing this experiment the student will be able to differentiate best arrangement of a set of ideal reactors] 10. Determination of RTD and dispersion number for CSTRs in series [After completing this experiment the student will be able to apply the tracer concentration time data of CSTRs in series to calculate the external age distribution function., the cumulative distribution function, the mean residence time, and the variance]
Course Outcomes:	
	After the completion of the course the student should be able to 1. Familiarize with suitable measurement techniques and devices to measure concentration and temperature. 2. Able to employ various methods to determine the kinetics of reactions. 3. Able to quantify the effect of non-ideality of flow in chemical reactors.
Text Books:	
	1. Chemical Reaction Engineering, Octave Levenspiel, John Wiley & Sons, Singapore, 1998 3 rd Edition 2. Elements of Chemical Reaction Engineering, Fogler H.S., Prentice-Hall, NJ, 2006, 4th Edition 3. Chemical Engineering Kinetics, Smith J. M., McGraw Hill, N Y, 1981, 3 rd Edition
References:	

HEAT AND MASS TRANSFER

Many industrial processes in biotechnology involve heating and cooling. Although thermodynamics determines the direction of the flow of heat, knowledge of the modes of heat transfer enables us to estimate the time required for achieving the target temperature. This is critical for many biological processes that are highly sensitive to small changes in temperature.

Mass transfer involves concentration changes due to transfer of molecules from one phase to another. Mass transfer principles are used in biological processes and industrial biotechnology. This course is a prerequisite for bioprocess engineering and bioreactor design.

Course Objectives:

- To understand the physical phenomena associated with conduction and convection, Newton's law of cooling, and the significance of non dimensional parameters in convection heat transfer.
- To use empirical correlations to analyze external and internal, forced and free convection problems.
- Analyze theories to correlate interphase mass transfer
- Analyze continuous steady state distillation processes
- Analyze single and multistage extraction operations

Unit- I	**8 hrs**

Introduction: Modes of heat transfer. Basic laws of heat transfer. Analogy between heat flow and electrical flow. Conduction: The Fourier heat conduction equation. Steady state and one dimensional heat conduction through plane wall, cylindrical wall, spherical wall and composite structures. Heat transfer from extended surfaces. Three dimensional heat conduction equation. Unsteady state conduction: simplified case for systems with negligible internal resistance, basic equation, equation for different geometries.

Learning Outcomes:

At the end of this unit, the student will be able to

- Apply law of conservation of mass and energy to a control volume or control surface.
- Understand the origin of Fourier's law
- Build a mathematical model based on boundary conditions
- Solve the general heat diffusion equation for one-dimensional steady-state problems
- Analyze transient problems using the lumped capacitance method

Unit- II	**8 hrs**

Convection: The convective heat transfer coefficient. Introduction to thermal boundary layer. Dimensionless numbers in heat transfer and their significance. Dimensional analysis. Forced convection: heat transfer by forced convection in laminar flow, turbulent flow, heat transfer in transition region between laminar and turbulent flow. Analogy between momentum and heat transfer. Reynolds, Colburn and Prandtl analogies. Natural convection: natural convection from vertical and horizontal surfaces. Grashoff number. Plate and frame heat exchanger, shell and tube heat exchanger.

Learning Outcomes:

At the end of this unit, the student will be able to

- explain convection and Newton's law of cooling
- Understand the significance of dimensionless parameters in convection heat transfer
- Apply dimensional analysis to determine heat transfer in forced and natural convection
- Apply empirical correlations to analyze external and internal, forced and free convection problems

Unit- III	**8hrs**

Introduction: Mass transfer operations, molecular diffusion in fluids, binary solutions, Fick's law, equation of continuity, steady state equimolal counter current diffusion, Stefan's diffusion, estimation of diffusivity of gases and liquids, theories of mass transfer. Interphase mass transfer: concept of equilibrium, diffusion between phases, material balances in steady state co-current and counter-current stage processes.

Learning Outcomes:

After completing this unit, the student will be able to

- Explain the concept of mass transfer
- Solve problems of mass transfer in diffusion, chemical reaction, and convection
- Explain the equations for the calculation of diffusional flux
- Analyze theories of interphase mass transfer.

Unit- IV	**8 hrs**

Distillation: Principles of VLE for binary systems, phase diagrams, relative volatility, ideal solutions, enthalpy concentration diagrams, flash vaporization, differential distillation (Rayleigh equation), steam distillation, continuous distillation, McCabe-Thiele method.

Learning Outcomes:

After completing this unit, the student will be able to

- Analyze continuous steady state distillation processes
- Explain pressure-composition diagrams for ideal solutions
- Explain enthalpy concentration diagrams
- Analyze material balance for distillation of binary mixtures
- Explain graphical procedure for calculating number of theoretical plates

Unit- V	**8 hrs**

Liquid-liquid Extraction: Liquid-liquid equilibria, choice of solvent for extraction, analytical and graphical solutions for single and multistage operations, continuous counter current operation.

Equipment: Mixer settler cascades, Rotating disc contactor, Scheibel extractor, Pulsed column, Centrifugal extractor.

Learning Outcomes:

After completing this unit, the student will be able to

- Explain separation of the constituents of a liquid solution by contact with another insoluble liquid
- Analyze Liquid-liquid equilibrium
- Explain concepts of single and multistage operations
- Select suitable equipments for extraction and heat exchange

Course Outcomes:

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

- Analyze Modes of heat transfer. Basic laws of heat transfer and unsteady state heat transfer
- Analyze Heat transfer by forced and free convection
- Analyze Mass transfer operations ,molecular diffusion in fluids and interphase mass transfer
- Analyze continuous steady state distillation processes
- Explain Concept about single and multistage operations and different types of equipments used in extraction

Text Books:

1. Warren L. McCabe, Julian C.Smith and Peter Harriott, Unit Operations Of Chemical Engineering, 7/e, McGraw Hill, 2005.
2. D.Q.Kern, Process Heat Transfer, Tata-McGraw Hill, 2001,
3. R.E. Treybal, Mass Transfer Operations, 3/e, McGraw Hill International Editions, 1981.
4. B.K. Dutta, Principles of Mass Transfer and Separation Processes, Prentice Hall of India, 2007.

References:

1. J.M. Coulson and J.F. Richardson, Chemical Engineering Volume-1, 4/e, The English Language book society and Permagon Press, Oxford, 2005.
2. William McAdams, Heat Transmission, 3/e, McGrawHill, 1985.

HEAT AND MASS TRANSFER LABORATORY

This laboratory course will reinforce the students' understanding of the analysis of applications pertaining to Heat and Mass Transfer through suitably designed experiments. These experiments will demonstrate the operation and the design of unit operations that incorporate heat and mass transfer phenomena.

List of Experiments:

PART A

1. Determination of Thermal conductivity of metal rod (steady state conduction).

After completing this experiment the student will be familiar with the development of the general heat diffusion equation based on Fourier's law and the principle of conservation of energy.

2. Calculation of thermal conductance in a unsteady state heat exchange unit.

[After completing the experiment the student is able to analyze transient problems]

3. Calculation of film and overall heat transfer coefficients in double pipe heat exchanger

[After completing the experiment the student is able to determine the effectiveness of double pipe heat exchanger]

4. Calculation of film and overall heat transfer coefficients in shell and tube heat exchanger

[After completing the experiment the student is able to determine the effectiveness of Shell and tube heat exchanger]

5. Heat transfer through composite walls

[After completing the experiment the student is able to determine the thermal conductivity of composite wall]

6. Unsteady state heat transfer unit

[After completing the experiment the student is able to determine the heat transfer coefficient in unsteady state heat transfer]

PART-B

7. Ternary liquid –liquid system

[After completing the experiment the student is able to determine the saturation isotherm (binodal curve) for the given system]

6. Liquid-liquid equilibrium system

[After completing the experiment the student is able to Determine the equilibrium data for the given Liquid-Liquid system]

7. Vapor-Liquid Equilibrium experiment

	[After completing the experiment the student is able to analyze the vapor-liquid equilibrium system] 8. Steam distillation [After completing the experiment the student is able to determine the efficiency of steam distillation] 9. Differential distillation [After completing the experiment the student is able to verify Rayleighs equation] 10 Arnolds cell [After completing the experiment the student is able to determine the diffusion coefficient of vapor through air film] 11. Liquid-liquid diffusion [After completing the experiment the student is Able to determine the diffusion coefficient of HCL in water] 12. Solid Liquid equilibrium experiment [After completing the experiment the student is able to determine the equilibrium distribution data for the given solid-liquid system]
Course Outcomes:	
	After the completion of the course the student should be able to 1. Utilize and operate measurement techniques and devices respectively to measure concentrations and temperatures. 2. Measure different variables of interest in unit operations involving heat and mass transfer. 3. Estimate heat and mass transfer coefficients for the unit operations involved.
Text Books:	
	1. N.S. Srinivas, Heat Transfer Laboratory Manual for Chemical Engineering Graduates, Create Space Independent Publishing Platform, 2014. 2. Abdul Matheen, Heat Transfer Laboratory Manual, 2/e, Laxmi Publications, 2007. 3. Awais Ali, Heat and Mass Transfer Lab Manual, 2014.
References:	

GENETIC ENGINEERING

Genetic engineering consists of a set of techniques for manipulating the genes, which constitute the basis of inheritance. The basic paradigm of genetic engineering namely recombinant DNA technology involves cutting segments of DNA from one organism and pasting it into a vector, which is then transferred to the organism to be modified. This process enables transfer of genes and traits from one organism to another. Genetic engineering is applicable to microbes as well as higher level organisms such as plants, animals and human beings. The principles and techniques of genetic engineering as well as applications of genetic engineering in agriculture, medicine and industry are described in this course.

Course Objectives:

- Explain principles of recombinant DNA technology
- Discuss the methods, tools and techniques for gene cloning and genome analysis.
- Describe methods for production of recombinant proteins.
- Describe the molecular techniques and their applications.
- List applications of rDNA technology in medicine, agriculture, industry and animal husbandry

Unit- I: Basics of rDNA technology	**8 hrs**

Isolation and purification of nucleic acids. Manipulation of DNA – Restriction and modification enzymes (nucleases, polymerases, ligases and topoisomerases). Characteristics of cloning and expression vectors, vectors based on plasmids, lamda phage, cosmids and artificial chromosomes BACs and YACs. Vectors for plant, yeast, and mammalian systems. Restriction mapping.

Learning Outcomes:

At the end of this unit, the student will be able to

- Describe DNA isolation, purification and manipulation (L2).
- Describe characteristics of cloning vectors (L2).
- Summarize use of restriction maps (L2)

Unit- II	**8 hrs**

Prokaryotic and expression host systems. Cloning strategies: construction of recombinant vectors. Introduction DNA into host systems (gene transfer methods for bacteria, plants and animals). Molecular techniques involved in study of expression of genes: Southern, Northern, Western, Dot and Slot blots, In-situ hybridization.

Learning Outcomes:

At the end of this unit, the student will be able to

- Select expression systems (L3).
- Describe strategies for construction of recombinant vectors (L1).
- Describe strategies for cloning of recombinant vectors (L1).

- Describe molecular techniques to analyze expression of genes (L1).

Unit- III	**8 hrs**

Construction of genomic and cDNA libraries. Screening of DNA libraries using probes and antisera. Preparation of labeled probes and primers. Maxam Gilbert, Sanger Coulson's, automated methods of DNA sequencing and Next Generation sequencing methods.

Learning Outcomes:

After completing this unit, the student will be able to

- Construct and evaluate DNA libraries (L4 and L5).
- Describe preparation of probes and primers (L2).
- Apply molecular techniques for DNA sequencing (L3).

Unit- IV	**8 hrs**

Techniques for nucleic acid amplification and analysis: PCR, Nested PCR, inverse PCR, RT-PCR, Hot start PCR, Real time PCR, qPCR, Molecular beacons, DNA finger printing, RAPD, RFLP and AFLP. Site directed mutagenesis.

Learning Outcomes:

After completing this unit, the student will be able to

- Describe methods for amplification of DNA and RNA (L2).
- Apply molecular techniques to understand gene expression profiling (L3).
- Describe the principles and applications of DNA finger printing(L1).

Unit- V	**8 hrs**

RNA silencing: design and applications of siRNA and anti-sense RNA. Applications of genetic engineering in medicine, agriculture, animal husbandry, environmental management and industry. Achievements, limitations and negative aspects of genetic engineering.

Learning Outcomes:

After completing this unit, the student will be able to

- Illustrate RNA silencing methods (L2).
- Describe applications of rDNA technology in medicine, agriculture, animal husbandry and Industry (L2).
- Discuss limitations and negative aspects of genetic engineering (L1).

Course Outcomes:

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

- Summarize the common methods of isolation of nucleic acids and enzymes used in molecular biology(L2).
- Explain the applications of genome sequencing methods(L2).
- Select best biological hosts for optimum production of a protein (L3).

	• Explain the principles of modern gene therapy(L2). • Describe the applications of rDNA technology(L1).
Textbooks:	
	1. T.A. Brown, Gene cloning and DNA analysis: an introduction, 6/e, Wiley- Blackwell, 2010. 2. D. S.T. Nicholl, An introduction to genetic engineering, 3/e, Cambridge University press, 2008.
References:	
	1. J.D. Watson, R.M. Meyers, A.A. Caudy and J.A. Witkowski, Recombinant DNA: genes and genomes - A short course, 3/e, W.H. Freeman and Co, 2007. 2. S.B. Primrose, R. Twyman, B. Old, Principles of gene manipulation, 6/e, Wiley-Blackwell, 2001.

GENETIC ENGINEERING LAB

Genetic Engineering Laboratory comprises of a series of techniques involved in the transfer genetic material from one organism to another. The primary objective the laboratory is to train the students in recombinant DNA Technology. For efficient learning lab course, students should have a basic knowledge on genetics and molecular biology.

At least 10 of the following experiments:

Expt.1. Isolation of genomic DNA from plants

At the end of his experiment, student will be able to isolate genomic DNA from plants

Expt.2. Determination of plant genomic DNA concentration and purity

At the end of his experiment, student will be able to assess the purity of the isolated DNA

Expt.3. Separation of plant genomic DNA on agarose gel electrophoresis

At the end of his experiment, student will be able to separate the DNA and visualize it

Expt.4. Isolation of plasmid DNA from *E.coli* culture

At the end of his experiment, student will be able to isolate plasmid DNA from bacterial culture

Expt.5. **Separation of plasmid DNA on agarose gel electrophoresis**

At the end of his experiment, student will be able to separate the plasmid DNA and visualize it

Expt.6. **Restriction digestion of □ phage DNA**

At the end of his experiment, student will be able to cut the DNA using enzymes

Expt.7. **Ligation of the DNA digested by restriction endonucleases**

At the end of his experiment, student will be able to join two DNA fragments and clone them into a vector

Expt.8. **Preparation of competent *E.coli* cells**

At the end of his experiment, student will be able to prepare the competent *E.coli* cells for transformation

Expt.9. **Transformation of competent *E.coli* cells with ligated plasmid and selection of positive colonies through Blue-white screening method**

At the end of his experiment, student will be able to perform transformation and screen the positive colonies

Expt.10. Studying the expression of cloned genes (GFP)

At the end of his experiment, student will be able to study the expression of cloned genes

Expt.11. PCR amplification of DNA using gene specific primers

At the end of his experiment, student will be able to amplify the DNA using PCR

Expt.12. Southern blotting of plant genomic DNA

At the end of his experiment, student will be able to transfer the DNA from gel onto a membrane for performing the hybridization

Expt.13. DNA finger printing through RFLP and RAPD

At the end of his experiment, student will be able to study the polymorphisms among organisms

Expt.14. Regulation of gene expression

At the end of his experiment, student will be able to study how a gene can be regulated by using reporter genes

References:

1. J.F. Sambrook and D.W. Russell, eds. Molecular Cloning: A Laboratory Manual, 3rd ed., Vols 1,2 and 3. Cold Spring Harbor Laboratory Press, 2001.

2. K.V.Chaitanya. Cell and Molecular Biology: A Lab Manual. PHI Learning Pvt. Ltd, India, 2013.

BIOPROCESS ENGINEERING

Industrial scale production of bioproducts involves optimization of media, operational conditions, selection of bioreactor type and method for control of operational parameters at the optimum values. Models of microbial growth are utilized to estimate the time requirements and process efficiency. This course describes the methods for optimization of media, aeration rate, process parameters and bioreactor type.

Course Objectives:

- Identify differences between chemical processes and bioprocesses
- Explain principles of media design and optimization
- Explain principles of microbial growth kinetics
- Describe selection and operation of bioreactors
- Describe fermenter design

Unit- I	**8 hrs**

Definition and scope of bioprocess engineering. Bioprocess verses chemical processing: advantages and disadvantages. Substrates for bioconversions. Choice of microbes. Media design and optimization.

Learning Outcomes:

At the end of this unit, the student will be able to

- Define bioprocess engineering (L2)
- Compare chemical processes and bioprocesses (L3)
- Explain principles of media design and optimization (L2)

Unit- II	**8 hrs**

Aeration and agitation inbioreactors: Oxygen transfer in microbial systems, oxygen demand mass transfer theories, oxygen consumption and heat evolution in aerobic cultures, thermodynamic efficiency of growth. Measurement of volumetric mass transfer coefficient, power requirement in gassed and ungassed bioreactors, mixing and heat transfer in dispersed systems, biorheology.

Learning Outcomes:

At the end of this unit, the student will be able to

- Explain role of aeration and agitation in bioreactors (L2)
- Relate oxygen consumption to heat evolution in aerobic cultures (L3)
- Calculate power requirement of bioreactors (L5)

Unit- III	**8 hrs**

Kinetics for batch growth- unstructured non-segregated models, models for transient behavior in batch reactor.Batch and continuous bioreactors, growth in ideal chemostat, chemostat with recycle, multistage chemostat, fed-batch growth. Immobilized cell systems.

Learning Outcomes:

	After completing this unit, the student will be able to • Explain kinetics of batch growth (L2) • Model bioreactors (L5) • Describe principles and applications of immobilized cell systems (L1)

Unit- IV	**8 hrs**
Selection and operation of bioreactors. Bioreactor instrumentation and control, Scale-up of bioreactors: Introduction, criteria of scale-up, similarity criteria, scale-up methods	
Learning Outcomes:	

	After completing this unit, the student will be able to • Select bioreactors (L3) • Describe instrumentation for bioreactor operation and control (L1) • Utilize scale up methods (L3)

Unit- V	**8 hrs**
Design of a fermenter: Basic functions of a fermenter for microbial or animal cell culture. Aseptic operation and containment, body construction: construction material, temperature control, aeration and agitation, foam control system, factors affecting antifoam requirements, antifoam addition system. Regulatory constraints	
Learning Outcomes:	

	After completing this unit, the student will be able to • Explain requirements for design of a fermenter (L2) • Explain choice of materials for fermenters (L2) • Explain control of operating conditions in a fermenter (L2) • Describe regulatory constraints (L1)
Course Outcomes:	
	After the completion of the course the student should be able to • Explain requirements for design of a bioreactor (L2) • Calculate power requirements of a bioreactor (L3) • Explain kinetics of microbial growth (L2) • Explain control of operating conditions in a fermenter (L2) • Describe regulatory constraints (L1)
Text Books:	
	1. M. L. Shuler, F. Kargi, Bioprocess Engineering Basic Concepts, 2/e, Prentice Hall, 2002
References:	
	1. Pauline M Doran, Bioprocess Engineering Principles, Elsevier, 2005. 2. P.F.A. Stanbury, A. Whitaker, S.J. Hall, Principles of Fermentation Technology, 2/e, Pergamon, 1995.

BIOPROCESS ENGINEERING LABORATORY

At least 10 of the following experiments are required:

Insitu sterilization and sterile operation of large reactors

At the end of this experiment the student will be able to: know sterilization types and its operations.

Substrate processing – Pretreatment

At the end of this experiment the student will be able to: know different pretreatment methods and pretreat the different lignocellulosic biomass.

Media optimization by a) Plackett and Burman method b) Response surface methodology for media design.

At the end of this experiment the student will be able to: understand different design of experiments to optimize the media.

Microbial growth and product formation kinetics

At the end of this experiment the student will be able to: know Growth rate data fitting of microorganism using logistic equation

Measurement of Volumetric Oxygen transfer coefficient (KLa) by: a) Sodium sulphite method b) Dynamic gassing method

At the end of this experiment the student will be able to: estimate Volumetric Oxygen transfer coefficient (KLa)

Batch, Fed batch and continuous bioreactors for Biotech products

At the end of this experiment the student will be able to: understand difference between Batch, Fed batch and continuous bioreactors for Biotech products.

Residence time distribution in CSTR

At the end of this experiment the student will be able to: estimate Residence time distribution in CSTR

Solid state fermentation

At the end of this experiment the student will be able to: understand specificity of SSF and its process.

Production of citric acid by solid state fermentation

At the end of this experiment the student will be able to: estimate amount of citric acid produced by SSF

Production and recovery of Penicillin

At the end of this experiment the student will be able to: know production, recovery and estimate amount of Penicillin produced by SmF

Production and recovery of Vitamin B_{12}

At the end of this experiment the student will be able to: know production, recovery and estimate amount of Vitamin B_{12} produced by SSF

Optimization of parameters for Amylase production

At the end of this experiment the student will be able to: know production, recovery and estimate Amylase activity by SmF

Bulk production of tailored organisms

At the end of this experiment the student will be able to: know bulk production of tailored organisms
Text Book(s):
1. N.S. Wang, Biochemical Engineering Lab Manual, 2009.

IMMUNOTECHNOLOGY

The immune system is designed to prevent foreign organisms from causing harm to the body. Immunotechnology utilizes the components of the immune system for therapeutic and analytical applications. This course describes the components of the immune system, the mechanisms of immune response and application of this knowledge for selection of transplants and for the production of vaccines.

Course Objectives:

- Introduce the concepts of immunology
- Describe the structure and functions of immunoglobulins and complement proteins
- Introduce various immunological techniques
- Introduce hypersensitivity reactions and transplantation immunology.
- Describe models of immune deficiency

Unit- I	**8 hrs**

History of immunology; Types of immunity: Innate and adaptive. Cells of the immune system, T and B lymphocytes – Origin, activation, differentiation, characteristics and functions. Nature of T and B cell surface receptors. Macrophages phagocytosis, Primary and secondary lymphoid organs: Structure and function. Antigens, immunogen, Hapten, Adjuvant, Epitope. Super antigens. Major Histocompatibility Complex, Human Leukocyte antigens (HLA), Antigen presenting cells, Processing and presentation of antigens. Necrosis & Apoptosis.

Learning Outcomes:

At the end of this unit, the student will be able to

- Recall the history of immunology (L1)
- Summarize the basis of immune cell production. (L2)
- Distinguish structure and function of primary and secondary lymphoid organs. (L4)
- Explain the biological functions of antigens. (L2)
- Describe processing of antigens and mechanism of cell death. (L1)

Unit- II	**8 hrs**

Structure of immunoglobulin, Immunoglobulin classes and biological activities. Isotypes, Allotypes, Idiotypes. Immunoglobulin genes and antibody diversity, Class switching, Humoral and cell-mediated immune responses, Cytokines-Interleukins, Interferons, TNF. The Complement, pathways and consequences of complement activation.Tumor immunology: Definition, tumor antigens, immune response to cancer.

Learning Outcomes:

At the end of this unit, the student will be able to

- Outline the importance of immunoglobulins (L2)
- Explain the relationship between the cell and humoral immunity. (L2)
- Interpret the relationship of immunoglobulin genes and antibody diversity. (L2)
- Summarize the functions of cytokines. (L2)

	• Explain the biological consequences of complement proteins. (L2)

Unit- III	**8 hrs**
Antigen-antibody interactions: Antibody affinity and avidity, Precipitation reactions – Immunodiffusion, Radial immunodiffusion, double immunodiffusion, immunoelectrophoresis, Rocket immunoelectrophoresis, Agglutination reactions- Hemeagglutination and complement fixation, Immunoflourescence, RIA, ELISA, Immunoblotting, Flow Cytometry and Fluorescence, Hybridoma technology - Production of monoclonal antibodies and their applications. Catalytic antibodies.	

Learning Outcomes:

After completing this unit, the student will be able to

- Apply immunological techniques to diagnose various diseases. (L3)
- Explain the principles of Ag-Ab interactions. (L2)
- Describe the production of monoclonal antibodies (L1).

Unit- IV	**8 hrs**
Hypersensitivity: Immediate (type I, type II, type III) and delayed hypersensitivity reactions, Autoimmunity - organ specific (Hashimoto's thyroiditis) and systemic (Rheumatoid arthritis) diseases. Transplantation Immunology- auto, allo, iso and xenograft, Bone marrow and Kidney transplants, Graft rejection (Graft versus host rejection and host versus graft rejection mechanisms), Co stimulatory pathways, Immuno suppressive agents. Immunodeficiencies - SCID and AIDS.	

Learning Outcomes:

After completing this unit, the student will be able to

- List the hypersensitivity reactions and auto immune diseases and their types. (L1)
- understand the basics of transplantation immunology. (L2)
- understand the kidney and bone marrow transplantation. (L2)
- Describe immunosuppressive drugs and immunodeficiency disorders (L1)

Unit- V	**8 hrs**
Vaccines: Types of vaccines, Development, Production of peptide and DNA vaccines, Knockout mice, Transgenic mice as models of immune system diseases-Nude mice and SCID mice.	

Learning Outcomes:

After completing this unit, the student will be able to

- outline the principles of vaccine development. (L2)
- explain the potential of transgenic mice (L2)
- analyse the models for SCID (L4)

Course Outcomes:

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

- describe the molecular basis of the immune response (L1)
- understand the basics of transplantation immunology. (L2)

	• Describe immunosuppressive drugs and immunodeficiency disorders (L1) • outline the principles of vaccine development. (L2) • explain the potential of transgenic mice (L2)
Text Books:	
	1. Thomas J. Kindt, Barbara, A. Osbarne, Richard A. Goldsby, Kuby Immunology, 8^{th} Edition, W.H Freeman, 2018. 2. P.M. Lydyard, A. Whelan & M.W Fanger, Instant notes in Immunology, 1^{st} Edition, Viva publishers, 2008.
References:	
	1. William E. Paul, Fundamentals of Immunology, 7^{th} Edition, Lippincott and Wilkins, 2012. 2. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roit, Roitt's Essential Immunology, 12th edition, Wiley Black well, 2011.

IMMUNOTECHNOLOGY LAB

The establishment of immunology lab will enable the student to gain a broad foundation base and build upon that base for understanding the defense mechanisms of the human body and advanced techniques in diagnosis of diseases. The lab will support the advanced courses for the student of graduate school or post graduates or entering medical school or research scholars or for any student actively involved in the medical healing arts.

List of Experiments:

1. Differential count of White blood cells by haemocytometer
   After completion of this experiment, the student will be able to use haemocytometer and will differentiate different white blood cells based on shape of nucleus
2. Estimation of hemoglobin by Sahli's method
   After completion of this experiment, the student will be able to determine the hemoglobin content and interpret the normal and anemic conditions
3. Widal test for identification of Salmonella Typhi
   After completion of this experiment, the student will be able to understand the antigen and antibody specificity
4. Identification of blood group antigens
   After completion of this experiment, the student will be able to identify blood group antigens
5. Agglutination inhibition test to detect pregnancy
   After completion of this experiment, the student will be able to understand the agglutination inhibition test
6. Antigen/ antibody detection by Enzyme linked immune sorbent assay
   After completion of this experiment, the student will be able to detect Ag/ Ab by Enzyme linked immune assay
7. Detection of antigen / antibody by Immuno Diffusion test
   After completion of this experiment, the student will be able to detect Ag/ Ab by immune diffusion method
8. Immunoelectrophoresis
   After completion of this experiment, the student will be able to learn Ag/ Ab detection by electrophoresis
9. Protein immunoblotting (Western blotting) technique
   After completion of this experiment, the student will be able to learn to detect multiple Ag/Ab by blotting technique
10. Flow cytometry
    After completion of this experiment, the student will be able to understand the principle of flow cytometry

Course Outcomes:

	After the completion of the course the student should be able to • Use haemocytometer • explain bacterial agglutination • Detect the Ag/Ab by immunological techniques • Understand the principle of immunoelectrophoresis, western blotting • Explain the principle of flow cytometry
Text Books:	
References:	
	1. Practical Immunology A Laboratory Manual, Karthik Kaliaperumal and Senbagam Duraisamy Senthilkumar Balakrishnan, Lambert publishers Academic publishers 2017 2. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited 3. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York. 4. . Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg. 5. Richard C and Geiffrey S. (2009). Immunology.6th edition.Wiley Blackwell Publication

BIOINFORMATICS

Modern high throughput methods generate vast amounts of biological data. Bioinformaticsenables us to validate, store, retrieve and analyze these data sets. This course introduces the datastructures and algorithms that enable us to compare, classify and predict the function of biologicalsequences.

Course Objectives:

- describe nature and type of information available in biological databases (L1)
- explain the principles of sequence alignment (L2)
- analyze the algorithms for phylogenetic analysis (L3)
- explain the principles of protein structure prediction (L2)
- explain the principles of structural and functional genomics (L2)

Unit- I	**8 hrs**

Introduction to Biological data types and databases. Brief introduction to information available in the following databases (details to be covered in practicals): NCBI-Genebank, PIR, PFAM, PDB, GOLD. Sequence analysis: introduction. Similarity matrices – PAM and BLOSUM.
BLAST Tool for searching sequence databases. Description of the BLAST algorithm

Learning Outcomes:

At the end of this unit, the student will be able to

- summarize the advantages of storing information in databases (L2)
- identify the most appropriate database for each type of biological entity (L5)
- calculate similarity of two aligned sequences (L3)
- summarize the principles of the BLAST algorithm (L2)
- describe the applications of BLAST and its variants (L1)

Unit- II	**8 hrs**

Pairwise sequence alignment using dynamic programming. Needleman & Wunsch algorithm for global alignment. Smith-Waterman algorithm for local alignment. Dynamic programming for sequence alignment with affine gap penalties. Searching for repeats and partial overlaps using dynamic programming.

Learning Outcomes:

At the end of this unit, the student will be able to

- apply dynamic programming for pairwise sequence alignment algorithms (L3)
- evaluate the score for optimal global alignment of a pair of sequences (L5)
- evaluate the score for optimal local alignment of a pair of sequences (L5)
- evaluate the score for optimal end overlap alignment of a pair of sequences (L5)
- predict the optimal alignment to find repeats of one sequence in another (L2)

Unit- III	**8 hrs**

Phylogenetic analysis. Distance based methods: UPGMA and Neighbor joining. Classical parsimony and weighted parsimony methods. Branch and bound.
Multiple sequence alignment. Multidimensional dynamic programming. Progressive alignment and profile alignment. Sankoff and Cedergren method for Simultaneous alignment and phylogeny.

Learning Outcomes:

After completing this unit, the student will be able to

- describe the principles and algorithms used for molecular phylogenetic analysis (L1)
- describe the principles and methods of multiple sequence alignments (L1)
- solve problems in phylogenetic analysis (L3)
- compare the distance based and character based algorithms for phylogenetic analysis (L5)
- compare the available algorithms for multiple sequence analysis (L5)

Unit- IV	**8 hrs**

Prediction of transmembrane helices. Prediction of secondary structure from protein sequence – Chou-Fasman rules, neural networks. Prediction of protein conformation from protein sequence - Information theoretical methods: Homology and threading. Prediction using Force fields (Basic concepts only, regarding Energy minimization, molecular dynamics and simulated annealing). Forces involved in protein-protein, protein-DNA, protein-ligand and DNA-DNA interactions.

Learning Outcomes:

After completing this unit, the student will be able to

- compare the methods for prediction of transmembrane helices and secondary structure (L5)
- describe the principles of neural networks (L1)
- describe the concepts related to force fields (L1)
- describe the principles of molecular mechanics (L1)
- compare the information theoretical and force field based methods for protein structure prediction (L5)

Unit- V	**8 hrs**

Computational problems in genome sequencing (concepts). Graph theoretical formulation of the fragment assembly problem. Hamiltonian path and Eulerian path based algorithms. Gene prediction - statistical and similarity based approaches. Overview (concepts only) of methods for gene annotation. K-means and SOM algorithms for analysis of gene expression data.

Learning Outcomes:

After completing this unit, the student will be able to

- understand the computational problems and concepts of structural and functional genomics (L2)
- compare the algorithms available for structural and functional genomics (L4)
- predict genomic sequence from fragment sequence data by using a Hamiltonian path based algorithm (L6)
- predict genomic sequence from fragment sequence data by using a Eulerian path based algorithm (L6)
- predict promoter sites by using genomic sequence data and a position specific score matrix (L6)

Course Outcomes:

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

	• list biological databases related to biochemicals, proteins and nucleic acids (L1) • assess similarity of biological sequences (L5) • solve problems in phylogenetic analysis (L6) • predict protein structure based on sequence information and structure of homologs (L6) • construct genomic sequences from fragments (L6)
Text Books:	
	1. R. Durbin, S. Eddy, A. Krogh, G. Mitchison, Biological sequence analysis: Probabilistic models of proteins and nucleic acids, Cambridge University Press. 1998. 2. P. Pevzner and R. Shamir. Bioinformatics for Biologists. Cambridge University Press. 2011.
References:	
	1. A. Leach, Molecular modeling: principles and applications, 2/e, Pearson, 2009. 2. Teresa K. Attwood, Stephen R. Pettifer, David Thorne. Bioinformatics Challenges at the Interface of Biology and Computer Science: Mind the Gap. John Wiley & Sons, 2016. 047003548X, 9780470035481. 3. D. Mount, Bioinformatics: Sequence and Genome analysis, 2/e. CBS publishers. 2005. 4. T. Schlick, Molecular modeling and simulation, Springer-Verlag, 2002.

PLANT BIOTECHNOLOGY

The plant biotechnology course is an essential component of biotechnology program. The course enables students to explore the skills of basic operations such as media preparation, plantlet regeneration and acclimatization. The technique expose student for large scale propagation of plants, their adaptations to climatic changes as well as selection and genetic modifications for disease resistance, herbicide tolerance, abiotic stress tolerance.		
Course Objectives:		
	• Introduce the concepts of screening, isolation and maintenance of industrially important microorganisms. • Describe the production of organic acids and fermented beverages • Describe the applications of secondary metabolites, antibiotics and enzymes. • Introduce the commercial aspects of fermented foods. • Describe the application of recombinant DNA technology for production of therapeutics	
Unit- I : Plant tissue culture and biotechnology		**8 hrs**
Introduction, significance, history, plant tissue culture media, plant growth regulators, Principle and pathways of in vitro plant regeneration- totipotency, cell differentiation, callogenesis, rhizogenesis, organogenesis, somatic embryogenesis, Clonal (Micro) propagation- business and opportunity.		
Learning Outcomes:		
	At the end of this unit, the student will be able to • Explain the principles and pathways of plant regeneration (L2) • Compare organogenesis and somatic embryogenesis for plantlet regeneration (L3) • Apply micro-propagate techniques for large scale plants production (L3) • estimate the cost of regenerated plants (L3)	
Unit- II : Applications of plant tissue culture technique		**8 hrs**
Haploid plant production, Protoplast technology- isolation, culture, somatic hybrids and cybrids production, Germplasms conservation- cryopreservation, Gene banks, Synthetic seeds technology, Somaclonal variations- origin, cause and in vitro selection, Virus indexing.		
Learning Outcomes:		
	At the end of this unit, the student will be able to	

<table>
<tr><td></td><td colspan="2">Explain importance and applications of haploids, protoplast, somatic hybrids in plant improvement (L2)
Select and regenerate variant and disease free plants (L4)
Describe germplasms conservation, gene bank and synthetic seed technology (L1)</td></tr>
<tr><td colspan="2">Unit- III : Scale-up propagation</td><td>8 hrs</td></tr>
<tr><td colspan="3">Callus and cell culture system- isolation, culture, growth, viability and applications, Secondary metabolite production, biotransformation, Bioreactor- design and models for mass cultivation of plant cells, Hairy root bioreactor for secondary metabolite production, Automation in plant tissue culture.</td></tr>
<tr><td colspan="3">Learning Outcomes:</td></tr>
<tr><td></td><td colspan="2">After completing this unit, the student will be able to
Explain growth kinetics and viability in callus and suspension cultures (L2)
Compare shake flasks and bioreactor system for plant cell cultures (L3)
Model and design bioreactors for mass production (L5)
analyze secondary metabolite production from cells and hairy roots in bioreactor (L2)</td></tr>
<tr><td colspan="2">Unit- IV: Genetic Transformation-basic principles and applications</td><td>8 hrs</td></tr>
<tr><td colspan="3">Plant genetic transformation technology: chimeric gene construction, Methods of gene transfer, Vectors of genetic transformation- Ti based vectors, T-DNA, mechanism of Agrobacterium gene transfer, , viral vectors, Chloroplast transformation, Gene Silencing- RNA editing, Field techniques for transgenic plants.</td></tr>
<tr><td colspan="3">Learning Outcomes:</td></tr>
<tr><td></td><td colspan="2">After completing this unit, the student will be able to
apply basic principles of genetic engineering for transformation of plant cells (L2)
Explain the mechanisms of gene silencing and editing (L2)
Relate field techniques for containments and cultivation of transgenic plants (L3)</td></tr>
<tr><td colspan="2">Unit- V: Transgenic plants status</td><td>8 hrs</td></tr>
<tr><td colspan="3">Delayed ripening, Disease resistance-fungal, bacterial, viral, Herbicide resistance, Stress tolerance, Enhanced nutritional properties- Iron and Vit-A (Golden Rice), Plantibody, Plant cell chemical factory, Current global status and limitations of transgenic crops, Ethical and legal issues related to GM crops, Regulation of GM crops in India.</td></tr>
<tr><td colspan="3">Learning Outcomes:</td></tr>
</table>

	After completing this unit, the student will be able to • analyze the genetic improvements of plants for various traits (L3) • Explain transformed cells as the chemical factory for metabolite production in plants (L2) • Describe regulatory constrains, legal and ethical issues of GM crops (L1)
Course Outcomes:	
	After the completion of the course the student should be able to • apply fundamental knowledge of in vitro plant propagation in laboratory and industry (L2) • Develop protocols for large scale micropropagation system, germplasm conservation, virus elimination (L3) • Explain screening and selection of haploids, somatic hybrids, and other variants for biotic and abiotic resistance (L2) • Improvise secondary metabolites through selection and genetic transformation (L3) • calculate the cost of tissue cultured plant and the enterprises (L5) • Undertake higher education and research as career in Plant Biotechnology (L5)
Text Books:	
	1. H. S. Chawla, Introduction to Plant Biotechnology, 3/e, CRC Press, 2009. 2. A. Slater, N. Scott, M. Fowler, Plant Biotechnology: The Genetic Manipulation of Plants, 2/e, Oxford University Press, India, 2008. 3. Purohit S.D, Introduction to Plant Cell, Tissue and Organ Culture Paperback – 2012.
References:	
	1. L. Pena, (Editor), Trangenic Plant: Methods and Protocols (Methods in Molecular Biology Series Vol. 286)”, Hanumana PressTotowa, New Jersey, USD, 2005. 2. Agnès E Ricroch, Surinder Chopra, Shelby Fleischer. Plant Biotechnology: Experience and Future Prospects. Springer International Publishing, pp.XIII, 291, 2014, 978-3-319-06891-6. 3. Functions and Biotechnology of Plant Secondary Metabolites 2nd ed (2010). Wink, M. Wiley-Blackwell

PLANT BIOTECHNOLOGY LABORATORY

At least ten of the following:

Safety rules and regulation, Laboratory requirements: Equipment, Glass ware, Chemicals; Laboratory organization and laboratory techniques.

1. Preparation of stock solution for Murashige & Skoog's (1962) (MS) medium.
2. Establishment of seed culture.
3. Induction and establishment of callus culture.
4. Haploids from anther culture.
5. Storage organ culture.
6. Axillary bud culture.
7. Leaf disc culture.
8. Subculture and multiplication of callus.
9. Shoot tip culture.
10. Zygotic embryo culture and somatic embryogenesis.
11. Artificial seeds production and plantlets regeneration.
12. Cell suspension culture.
13. Isolation and culture of protoplasts.
14. Agrobacterium mediated genetic transformation and hairy root culture.
15. In vitro rooting/ germination of somatic embryo and regeneration of complete plant.
16. Soil transfer, hardening and acclimatization of plantlets.

Text Book(s)

1. S.Nagar, M. Adhav, Practical Book of Biotechnology and Plant Tissue Culture. S Chand, 2010.
2. C.C. Giri, A. Giri, Plant Biotechnology: Practical Manual, I K International Publishing House, 2007.

References

1. C.A. Beyl, R.N. Trigiano (Editors), Plant Propagation Concepts and Laboratory Exercises, 2/e, CRC Press, Tylor and Francis Group LLC, 2015.
2. E.F. George, M.A. Hall, G.J. De Klerk, (Editors) Plant Propagation by Tissue Culture, Volume 1 & 2, 3/e (Volume 1, Available online), 2008.
3. V.M. Loyola-Vargas, F. Vazquez-Flota (Editors), Plant Cell Culture Protocols, 1/e, Springer-Verlag New York, LLC, 2005.
4. J.H. Dodds, L.W. Roberts, J. Heslop-Harrison, Experiments in Plant Tissue Culture, 3/e, Cambridge University Press, 2004.

PROCESS DYNAMICS AND CONTROL

Bioprocesses are extremely sensitive to variations in temperature, oxygenation level, pH, ionic strength and shear. The response of a system to changes in external variables is time dependent. Hence the current state of the system has to be evaluated and the changes required to restore the system to the desired state have to be calculated. This course describes the dynamic models and control methods used for maintenance of reaction conditions.

Course Objectives:

- operate a process at the desired operating conditions, safely and efficiently, while satisfying environmental and product quality requirements.
- develop models of important physical process systems.
- design various control systems.
- apply the control systems in various chemical and biochemical processes

Unit- I	**8 hrs**

Linear Open-loop Systems: Response of First-Order Systems, Physical examples of First-Order systems, Response of First-Order Systems in series, Second-Order Systems, Transportation Lag.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the importance of modeling and dynamics in process control (L2)
- Distinguish first order and higher order systems. (L4)
- Derive modelling equations for various systems. (L5)
- Predict the responses of systems for common forcing functions. (L6)

Unit- II	**8 hrs**

Linear Closed-Loop Systems: The control system, Controllers and Final Control elements, Closed-Loop transfer functions, Routh Stability, Root Locus.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the concept of control systems. (L2)
- Distinguish various controllers. (L4)
- choose the correct type of controller for a given process. (L3)
- Predict the stability of a system. (L6)

Unit- III	**8 hrs**
Frequency Response: Introduction to frequency response. Control system design by frequency response.	
Learning Outcomes:	
After completing this unit, the student will be able to • Understand the concept of frequency response. (L2) • predict the frequency response of a system. (L6) • choose the optimum values of controller parameters. (L3)	
Unit- IV	**8 hrs**
Process Applications: Cascade control, Feed forward control, Ratio control, Selective Controllers, Split Range Controller, Controller tuning, Control valves.	
Learning Outcomes:	
After completing this unit, the student will be able to • Understand the concepts of advanced controllers used in the industry. (L2) • determine the stability of the system. (L5) • choose the suitable controller mechanism. (L3) • define the controller parameters for satisfactory response. (L1)	
Unit- V	**8 hrs**
Applications of controllers in Bioprocesses: Measurement and control of biochemical process variables pH, dissolved oxygen, viscosity, temperature, NADH, agitation rate and foam. Data logging, analysis and computer control of bioreactors.	
Learning Outcomes:	
After completing this unit, the student will be able to • list the process variables in fermentation. (L1) • control process parameters in fermentation. (L3) • control operation of bioreactors using computers. (L3	
Course Outcomes:	
After the completion of the course the student should be able to • analyse process controls and their applications (L4) • assess the dynamics of first and higher order systems. (L4) • evaluate the stability of controllers used in process industry (L5) • understand the functioning of different controllers. (L2) • Apply control systems for bioreactor operation	
Text Books:	

1. Process Systems Analysis and Control, 3rd Edn. S. E. Leblanc, Donald R.Coughanowr, McGraw-Hill Inc., 2009.
2. Stanbury, P.F.A., Whitaker & Hall, Principles of Fermentation Technology, 3/e Elsevier, 2017

Reference Books:

3. Seborg, Edgar, Millichamp, Doyle Process dynamics and control, 3/e John Wiley & Sons, 2010
4. Biochemical engineering fundamentals, Bailey and Ollis. 2nd Ed. 1986. McGrawHill.

	POs												PSOs		
CO	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2	3	2	1	2	2	2	2	2	2	3	2	2
Avg	3.0	2.0	2.0	3.0	2.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	3	2	2

PROCESS DYNAMICS AND CONTROL LABORATORY

List of Experiments:

1. Calibration of thermocouples.
   At the end of this experiment the student will be able to:
   Learn methodology for calibration of thermocouples

2. Calibration of rotameter with compressible fluid.
   At the end of this experiment the student will be able to:
   Learn methodology for calibration of a rotameter

3. Response of resistance thermometer
   At the end of this experiment the student will be able to:
   measure the response of a resistance thermometer

4. Response of bare mercury in glass thermometer.
   At the end of this experiment the student will be able to:
   Measure the response of mercury in a glass thermometer

5. Response of bare mercury in glass thermometer with thermal well.
   At the end of this experiment the student will be able to:
   Measure the response of mercury in glass thermometer with thermal well

6. Response of U-tube manometer.
   At the end of this experiment the student will be able to:
   Measure the response of a U-tube manometer

7. Response of single-tank liquid-level system
   At the end of this experiment the student will be able to:
   Measure the response of a single-tank liquid-level system

8. Response of two-tank interacting liquid-level system.
   At the end of this experiment the student will be able to:
   Measure the response of a single-tank liquid-level system

9. Response of two-tank non-interacting liquid-level system.

   At the end of this experiment the student will be able to:

   Measure the response of a two-tank interacting liquid-level system

10. Study of ON-OFF control action.

   At the end of this experiment the student will be able to:

   Demonstrate ON-OFF control action

Text Books:

1. D. Mukund, B. Nitin, Process Dynamics Laboratory, LAP Lambert Academic Publishing, 2011.
2. D.R. Coughnowr, S.E. LeBlanc, Process Systems Analysis and Control, 3/e, McGraw- Hill.

BIOSEPARATION TECHNOLOGY

Products of interest have to be separated from biomass and remaining constituents of the media at the end of fermentation. The separation of the desired products is a challenging task that often accounts for a major part of the cost of an industrial bioprocess. This course describes the techniques and processes used for separation and purification ofbioproducts.

Course Objectives:

- introduce the methods for the separation of bioproducts (L1)
- describe the various methods for the purification of recombinant proteins. (L1)
- explain the mechanism of membrane fouling. (L2)
- create process flow sheet using the unit procedure concept. (L5)
- explain nucleation and growth of crystals (L2)

Unit- I	**10 hrs**

Overview of bioseparation, classification of bioproducts; Recovery of intracellular products: Cell disruption methods: physical methods (osmotic shock, grinding with abrasives, solid shear, liquid shear), chemical methods (alkali, detergents), enzymatic methods. Extracellular Products.

Learning Outcomes:

At the end of this unit, the student will be able to

- understand the mechanical methods of cell lysis.(L2)
- Understand the chemical methods of cell lysis. (L2)
- Describe Electrokinetic phenomena of cells. (L1)

Unit- II	**8 hrs**

Separation of cells and other insolubles from fermented broth: Sedimentation, filtration (pretreatment, filtration theory, continuous rotary filters), microfiltration, ultrafiltration, centrifugation (batch, continuous and basket), Precipitation.

Learning Outcomes:

At the end of this unit, the student will be able to

- calculate filter efficiency using Darcys law.(L2)
- select appropriate filter media and equipment. (L3)
- explain factors that influence protein solubility. (L2)
- explain Sedimentation and precipitation processes. (L2)

Unit- III	**8 hrs**

Extraction: Phase separation and partioning equilibria, liquid-liquid extraction methods, reciprocating-plate column, centrifugal extractor.
Adsorption: Theory of adsorption, adsorption isotherms, industrial adsorbents, adsorption types.

Chromatography: ion-exchange, column chromatography.

Learning Outcomes:

After completing this unit, the student will be able to

- explain adsorption isotherms. (L2)
- list different unit operations for biochemical product recovery. (L1)
- Describe the extraction of biochemical products
- understand the principles involved in chromatography techniques (L2)

Unit- IV	**8 hrs**

Crystallization: Crystallization theory, rate of nucleation and rate of crystal growth, particle size distribution of crystals, batch crystallizer, model for Mixed-Suspension-Mixed-Product -Removal (MSMPR) crystallizer.
Drying of bioproducts, methods of drying, equipment for drying, equilibrium moisture content of bioproducts, rate of drying curves, constant rate drying period, falling rate drying period, freeze drying.

Learning Outcomes:

After completing this unit, the student will be able to

- Understand the principles involved in crystallization and drying operations (L2)
- demonstrate the working of MSMPR crystallizer (L2)
- design dryers and crystallizers for the separation of biomolecules(L6)

Unit- V	**8 hrs**

Product recovery: Ethanol, Citric acid, Penicillin, Enzyme, Insulin.
Economics of Bioproducts.

Learning Outcomes:

After completing this unit, the student will be able to

- Understand the recovery of primary metabolites (L4)
- Understand the recovery of secondary metabolites (L4)
- Understand the recovery of fungal products (L4)
- Estimate the cost requirements of downstream processing(L5)

Course Outcomes:

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

- describe the various methods for the purification of recombinant proteins. (L1)
- list unit operations for biochemical product recovery. (L1)
- design equipment for the separation and purification of bioproducts (L6)
- create process flow sheet (L5)
- Estimate the cost requirements of downstream processing(L5)

Text Books:

	1. P.A. Belter, E.L. Cussler & Wei-Shou Hu, Bioseparations: Downstream Processing for Biotechnology, Wiley-Interscience. 2012.
References:	
	1. R.G. Harrison, P. Todd & S.R. Rudge, Bioseparation Science and Engineering, Oxford University Press, 2006. 2. McCabe, Smith & Harriot, Unit Operations of Chemical Engineering, 7th edition McGraw Hill book company, 2014. 3. J.A. Asenjo. Separation Processes in Biotechnology, CRC Press, 1990.

Bioseparation Technology Lab

1. **Cell disruption by chemical method.**
2. **Cell disruption by mechanical method.**
3. **Product recovery by membrane filtration.**
4. **Separation of product using rotary vacuum Evaporation**
5. **Separation of bioproduct using adsorption.**
6. **Biomass removal by flocculation / Centrifugation method.**
7. **Purification of ethanol using distillation method.**
8. **Dehydration and estimation of drying time of a sample using tray dryer.**
9. **Purification of antibiotic using liquid-liquid extraction.**
10. **Enzyme Purification using Dialysis method / Salting out method.**

Reference:

1. **R.G. Harrison, P. Todd & S.R. Rudge, Bioseparation Science and Engineering, Oxford University Press, 2006.**
2. **S. Sadasivam & A. Manickam. Biochemical Methods, 3rd edition, New age publisher, 2009.**

ANIMAL BIOTECHNOLOGY

The investigations and interpretations in animal biotechnology had contributed to countless impact to the world. This course provides an introduction to basic techniques of cell, tissue and organ culture, isolation and Application of stem cells in medicine, cell culture reactors. This course is prerequisite for organ culture and tissue engineering, production of transgenic Animals.		
Course Objectives:		
	• Introduce the Basic techniques of cell, tissue and organ culture. • Impart knowledge of stem cells • Summarize cell culture reactors • Explain the organ culture and tissue engineering • Discuss the production of transgenic animals	
Unit- I		**8 hrs**
Basic techniques of cell, tissue and organ culture, Primary culture and subculture of cells. kinetics of cell growth, Properties of normal and transformed cells, Role of carbon-dioxide, serum and other supplements in cell culture, Different types of culture media- natural media, BSS, MEM, serum free media, Different methods for the estimation of cell viability and cytotoxicity, Applications of cell culture.		
Learning Outcomes:		
	At the end of this unit, the student will be able to • explain basic techniques of cell culture (L2). • explain the role of carbon dioxide and other suppliments in cell culture. (L2). • outline different types of culture media (L1). • explain different methods for estimation of cell viability (L2).	
Unit- II		**8 hrs**
Stem cells – Embryonic and adult stem cells, Isolation and culture of stem cells, Induced pluripotency of stem cells, Stem cell markers, Stem cell plasticity and differentiation, Application of stem cells in medicine, Apoptosis- mechanism and significance with reference to degenerative diseases – Parkinson's disease, stroke and diabetes.		
Learning Outcomes:		
	At the end of this unit, the student will be able to • recall the isolation and culture of stem cells (L1). • explain the types of stem cells and stem cell markers. (L2).	

	• explain applications of stem cells (L2). • Interpret the mechanisms in degenerative diseases (L3).	
Unit- III		**8 hrs**
Cell culture reactors; Scale-up in suspension; Scale and complexity; Mixing and aeration; Rotating chambers; Perfused suspension cultures; Fluidized bed reactors for suspension culture; Scale-up in monolayers; Multisurface propagators; Multiarray disks, spirals and tubes; Roller culture; Microcarriers; Perfused monolayer cultures.		
Learning Outcomes:		
	After completing this unit, the student will be able to • recall the cell culture reactors (L1). • summarize the scale-up and complexicity (L2). • explain the different reactors (L2).	
Unit- IV		**8 hrs**
Organ culture and tissue engineering: Organ cultures, histotypic cultures, three dimensional cultures, organotypic cultures. Production of bio-artificial skin, liver and pancreas, Tissue engineering- cell source and culture, culture of cells, design engineering of tissues, tissue modelling, Embryonic stem cell engineering.		
Learning Outcomes:		
	After completing this unit, the student will be able to • explain different types of culture (L1) • relate the tissue engineering with various organs (L1) • design engineering of tissues (L2)	
Unit- V		**8 hrs**
Production of Transgenic Animals -Mouse, cattle and fish by microinjection, retroviral vector method and embryonic stem cell method. Animal cloning-Somatic cell nuclear transfer and embryonic stem cell nuclear transfer methods. Biopharming and gene knockout technologies		
Learning Outcomes:		
	After completing this unit, the student will be able to • explain the production various transgenic animals (L2). • summarise animal clonning (L2). • explain biopharming and gene knockout technologies (L2).	
Course Outcomes:		
	After the completion of the course the student should be able to	

	• learn Basic techniques of cell, tissue and organ culture. • outline cell culture reactors • Explain the organ culture and tissue engineering • Discuss the production of transgenic animals • explain the production various transgenic animals
Text Books:	
	1. Ranga M.M. Animal Biotechnology. Agrobios India Limited, 2002 2. Ramadass P, Meera Rani S. Text Book of Animal Biotechnology. Akshara Printers, 1997.
References:	
	1. Freshney, R.I., "Culture of Animal Cells: A Manual of Basic Techniques and Specialized Applications", 6th Edition, John Wiley & Sons, 2010. 2. Portner, R., "Animal Cell Biotechnology: Methods and Protocols", 2nd Edition, Humana Press, 2007. 3. Masters J.R.W. Animal Cell Culture: Practical Approach. Oxford University Press.2000.

ADVANCED CELL BIOLOGY

Cells are the basic units of all higher level living organisms. This course describes the basis of cellular organization, cell-cell communication mechanisms and the molecular basis of cellular response to environmental signals. This course is useful to pursue advanced research in the fields of immunology and cancer biology.	
Course Objectives:	
• Provide a perspective on recent advances in cell biology • Familiarize the different approaches of cell biology • Impart the concept of cell signalling cascades • Introduce the mechanism of cell – cell communication • Explore the models and case-studies of signal transduction	
Unit- I	**6 hrs**
Introduction to cellular organization and metabolism: Energy trading within the cell: Cellular energy currencies: reduced nicotinamide adenine dinucleotide, nucleoside triphosphates, hydrogen ion gradient across the mitochondrial membrane, sodium gradient across the plasma membrane, inter-convertible mechanisms of energy currencies, feedback and feed-forward control of energy production.	
Learning Outcomes:	
At the end of this unit, the student will be able to • Demonstrate the energy trading within the cell (L2) • Explain about ion gradients in membranes (L2) • Compare feedback and fee-forward control of energy production (L2)	
Unit- II	**6 hrs**
Ions and Voltages: Potassium gradient and the resting voltage, Chloride gradient. Properties of carriers: sodium–calcium exchanger, calcium ATPase pump. Action potential: calcium action potential in sea urchin eggs, voltage-gated sodium channel in nerve cells.	
Learning Outcomes:	
At the end of this unit, the student will be able to • Explain ion channels and voltages in cells (L2) • List voltage-gated channels in cells (L1) • Explain the concept of action potential (L2)	
Unit- III	**6 hrs**

Intracellular signaling: Calcium, cyclic Adenosine Mono-Phosphate, cyclic Guanosine Mono-Phosphate, Receptor Tyrosine Kinases and the MAP kinase cascade, Protein Kinase B and the glucose transporter: working principle of insulin. Crosstalk between signaling pathways.	
Learning Outcomes:	
	After completing this unit, the student will be able to • Understand the intra-cellular signalling cascades (L2) • Explain the crosstalk between signaling pathways (L2) • Explain role of transporters in cell signalling (L2)
Unit- IV	**6 hrs**
Intercellular Communication: Classifying transmitters and receptors, Intercellular communication in action: case study of gastrocnemius muscular action. Nitric oxide signaling. Synapses between neurons: spatial summation, temporal summation, case study of gamma-amino butyric acid (GABA) neuro-transmitter.	
Learning Outcomes:	
	After completing this unit, the student will be able to • Classify transmitters and receptors (L2) • Explain intercellular communication (L2) • Demonstrate synaptic transmission (L2)
Unit- V	**6 hrs**
Cytoskeletal molecules: Microtubules, Microfilaments, Intermediate filaments, Cell-Cell junctions, Chemo and durataxis, Cell locomotion, cell migration and homing.	
Learning Outcomes:	
	After completing this unit, the student will be able to • Describe cytoskeletal molecules and their interaction (L2) • Explain the cell junctions (L2) • Explain the mechanism of cell locomotion (L2)
Course Outcomes:	
	After the completion of the course the student should be able to • Understand the energetics of cell metabolism • Understand the concepts of Ion gradients and Voltages in cells • Impart knowledge of inter and intracellular communications • Describe cellular locomotion (L2) • apply thermodynamic principles to biological systems. (L2)

	• analyze biological processes at the reductionistic level. (L4) • appreciate the potential of recombinant DNA technology. (L2)
Text Books:	
	1. Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter, Molecular Biology of the Cell, 6th Edition, 2014 2. Geoffrey M. Cooper, The Cell: A Molecular Approach 7th Edition, Oxford University Press; 2015.
References:	
	1. Francisco V. Sepiilveda and Francisco Bezanilla, Pumps, Transporters, and Ion Channels Studies on Their Structure, Function, and Cell Biology, Kluwer Academic /Plenum Publishers, 2005. 2. P.S. Verma, Cell Biology, Genetics, Molecular Biology: Evolution and Ecology, Chand (S.) & Co Ltd, India 2004.

ADVANCED CELL BIOLOGY LABORATORY

Any 10 of the following experiments:

19EBT244P	**Advanced Cell Biology Lab**	
Session	**Description of Experiments**	**Hrs**
1	Introduction to biological safety cabinets and CO_2 incubators	2
2	Aseptic techniques for cell culture	2
3	Principle and operation of an Inverted Microscope	2
4	Low Speed Centrifugation for separation of Cells from Whole blood	2
5	Isolation of Chloroplasts	2
6	Isolation of Mitochondria	2
7	Harvesting and Counting of cultured mammalian cells	2
8	Cryopreservation of Cells	2
9	Assessment of cell viability	
10	Preparation of whole cell extracts	2
11	Western blot	4
12	Flow cytometry	2
13	Cell separation with magnetic beads	2

ENVIRONMENTAL BIOTECHNOLOGY

Measurement of human induced changes to the environment and their remediation are essential for long term sustenance. Biotechnology based methods are useful for monitoring pollution and environmental remediation. This course describes the applications of biotechnology for pollution monitoring, methods for waste treatment and the applications of genetically engineered microbes for bioremediation.

Course Objectives:

- describe the relation between biodiversity and environmental pollution (L1)
- describe sources of pollution (L1)
- describe methods for biomonitoring of pollution (L1)
- describe applications of biotechnology for environmental remediation (L1)
- explain potential of genetically engineering microbes for bioremediation (L2)

Unit- I	**6 hrs**

Issues and Scope of Environmental Biotechnology: Introduction to Biodiversity, environmental pollution, chemical pesticides and their effects, metal pollution, bioaccumulation of toxicants, Biotechnological methods for measurement of pollution. Biomonitoring of air and water pollution, remediation of pollutants.

Learning Outcomes:

At the end of this unit, the student will be able to

- describe the relation between biodiversity and environmental pollution (L1)
- describe sources of pollution (L1)
- describe methods for biomonitoring of pollution (L1)

Unit- II	**6 hrs**

Biological Treatment of waste water: Aerobic suspended and attached growth system- activated sludge process, trickling filters, Rotating biological contractors (RBC). Anaerobic suspended and attached growth systems- anaerobic digestion, anaerobic filter process, UASB.
removal of biological nitrogen and phosphorus.

Learning Outcomes:

At the end of this unit, the student will be able to

- describe equipment for biological treatment of waste water (L1)
- describe aerobic and anaerobic processes for treatment of waste water (L1)
- describe removal of biological nitrogen and phosphorus (L1)
- explain the applications of fermentation in industry. (L2)

Unit- III	6 hrs
Treatment of waste water of food processing industries: Starch, Dairy, Fruit & Vegetable, Confectionary, Beverages, meat and vegetable oil .	
Learning Outcomes:	
	After completing this unit, the student will be able to • describe process for treatment of waste water from food processing industries (L1)
Unit- IV	**6 hrs**
Solid waste management- Sources, preliminary operations, sludge thickening, sludge stabilization, conditioning of sludge, dewatering, heat drying, disposal of sludge, Composting, Vermicomposting, Biofertilizers.	
Learning Outcomes:	
	After completing this unit, the student will be able to • describe methods for solid waste management (L1) • compare advantage of disadvantages of biofertilizers (L3)
Unit- V	**6 hrs**
Biodegradation and bioremediation- *In situ* and *ex situ* bioremediation, biodegradation of hydrocarbons, pesticides, herbicides and xenobiotics. Bioremediation of contaminated soil, Genetically engineered microorganisms in bioremediation. Phytoremediation.	
Learning Outcomes:	
	After completing this unit, the student will be able to • describe principles and applications of biodegradation (L1) • describe principles and applications of bioremediation (L1) • explain potential of genetically engineering microbes for bioremediation (L2)
Course Outcomes:	
	After the completion of the course the student should be able to • describe methods for biomonitoring of pollution (L1) • describe principles and methods for biological treatment of waste water (L1) • describe methods for solid waste management (L1) • describe principles and applications of biodegradation and bioremediation (L1) • explain potential of genetically engineering microbes for bioremediation (L2)
Text Books:	
	1. M.H. Fulekhar, Environmental biotechnology,2017, CRC publishers 2. U. Satyanarayana, Biotechnology, 1^{st} Edition, Books and Allied (P) Ltd, 2005

References:	
	1. Bruce E. Rittmann and Perry L. Mc Carty, Environmental Biotechnology: Principles and applications, Mc Graw Hill Company, 2012. 2. Martin Alexander, Biodegradation & Bioremediation, 2nd Edition, Academic press, 2012

ENVIRONMENTAL BIOTECHNOLOGY LABORATORY

List of experiments for Environmental Biotechnology Lab

Any five of the following experiments are required:

1. Assessment of microbes in air
2. Assessment of biological oxygen demand in Waste water
3. Demonstration of Activated sludge process for Waste water treatment
4. Demonstration of Anaerobic digestion for Waste water treatment
5. Composting
6. Production of biofertilizer
7. Biodegradation of plastics
8. Estimation of heavy metals in water
9. Environmental impact assessment of Fermentation Unit

Fermentation Technology

Fermentation is the process that started the era of industrial biotechnology. This technology can be utilized for the production of biochemicals, fuel and medicines. This course provides an introduction to the procedures involved in fermentation.	
Course Objectives:	
	• Introduce the concepts of screening, isolation and maintenance of industrially important microorganisms. • Describe the production of organic acids and fermented beverages • Describe the applications of secondary metabolites, antibiotics and enzymes. • Introduce the commercial aspects of fermented foods. • Describe the application of recombinant DNA technology for production of therapeutics
Unit- I	**9 hrs**
Introduction to Industrial Fermentations: Screening, isolation and maintenance of industrially important microorganisms. Types of fermentation processes, carbon and nitrogen sources, conventional and non- conventional raw materials and microbial metabolism..	
Learning Outcomes:	
	At the end of this unit, the student will be able to • Understand the significance of Industrially important microorganisms (L2) • Outline different fermentation processes (L2) • Explain the composition of raw materials (L2) • Relate microbial metabolism and raw materials (L2)
Unit- II	**9 hrs**
Production of primary metabolites: Production of organic acids: citric acid, acetic acid and lactic acid. Production of amino acids: L-glutamic acid and Lysine. Production industrial solvents and fermented beverages: ethanol, beer and wine.	
Learning Outcomes:	
	At the end of this unit, the student will be able to • Describe the production of citric acid, acetic acid and lactic acid. (L2)

	• Explain the difference in the production of ethanol, beer and wine. (L2) • Summarize fermentation processes for industrially important products. (L2)

Unit- III	**9 hrs**
Production of secondary metabolites: Production of antibiotics: penicillin and streptomycin. Production of industrial enzymes: amylases, proteases and pectinases.	
Learning Outcomes:	

	After completing this unit, the student will be able to • List various steps involved in the production of antibiotics.(L1) • Understand the production of industrial enzymes. (L1) • Differentiate between antibiotic and enzyme production. (L4)

Unit- IV	**9 hrs**
Food fermentation: Fermented milk foods: cheese. Fermented vegetable foods: Sauerkraut and soya sauce. Production of food and fodder yeast: Baker's yeast, food and fodder yeast.	
Learning Outcomes:	

	After completing this unit, the student will be able to • explain the production of fermented milk foods.(L2) • Identify the differences in the production of milk and vegetable fermented foods. (L3) • Analyse the role of microorganisms in production of fermented foods (L4)

Unit- V	**9 hrs**
Production of recombinant products: Production of recombinant biopolymers. Recombinant therapeutics: Production human insulin by bacterial and yeast expression systems. Production of human growth hormone by bacterial expression system.	
Learning Outcomes:	

	After completing this unit, the student will be able to • Apply recombinant DNA technology for production of therapeutics. (L2) • Summarize bacterial and yeast expression systems (L2) • Apply recombinant DNA technology for production of biopolymers. (L2)

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

	• understand the scope and importance of fermentation technology (L1) • distinguish between methods for production of primary and secondary metabolites (L2) • describe applications of recombinant DNA technology for pharmaceutical production (L1)
Text Books:	
	1. A. H. Patel, Industrial Microbiology, 2/e, MacMillan Publishers, 2012. 2. N. Okafor, Modern Industrial Microbiology and Biotechnology, Science Publishers, 2007.
References:	
	1. E. M. T. El Mansi, C. F. A. Bryce, A. L. Demain, A. R. Allaman, Fermentation Microbiology and Biotechnology, 3/e, Taylor and Francis, 2011. 2. W. C. Frazier, D. C. Westhoff and N. M. Vanitha, Food Microbiology, 4/e, McGraw Hill, 2014. 3. A. N. Glazer and H. Nikaido, Microbial Biotechnology: Fundamentals of Applied Microbiology, 2/e, Cambridge University Press, 2007. 4. G. Reed, Presscott and Dunn's Industrial Microbiology, 4/e, CBS Publishers and Distributors, 2004. 5. W. Cruger and A. Cruger, Biotechnology: A Textbook of Industrial Microbiology, Panima Publishing Corporation, 2003.

FERMENTATION TECHNOLOGY LABORATORY

Minimum of 8 experiments from the following:

1. Production of yeast
2. Production of bread
3. Production of wine
4. Production of cheese
5. Production of soya sauce
6. Production of alcohol
7. Estimation of alcohol
8. Production of glutamic acid
9. Production of an antibiotic
10. Production of a vitamin
11. Production of citric acid
12. Production of amylase

FOOD PROCESSING TECHNOLOGY

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The shelf life, texture and taste of most food materials can be improved by application of food processing technology. This course describes the methods used for food processing and food quality assessment.

Course Objectives:

- describe the scope and importance of food processing (L2)
- describe the application of membrane technology (L2)
- demonstrate design of filter module (L5)
- describe principles of formulation of food products (L3)
- describe the benefits of nutraceuticals (L2)

Unit- I **6 hrs**

Properties and processing theory of foods, Size reduction theory, Material transfer phenomena of foods, Effects of processing on nutritional properties and sensory characteristics, Food additives and its impacts on food safety, Principles of food processing, Processing of Food Commodities for high, medium and low moistures food, Theory and equipment of membrane technology for food, Microfiltration for food components separation and clarification, Ultrafiltration for protein concentration, Reverse osmosis processes for water quality.

Learning Outcomes:

At the end of this unit, the student will be able to

- Describe the scope of food processing (L1)
- Describe the benefits of processed food (L1)
- Explain the principles and applications of membrane technology for extending shelf-life of food (L2)

Unit- II **6 hrs**

Thermal food processing: Concepts and mechanisms of heat transfer, Sources of heat and methods of application to foods, concept of sterilization, blanching, pasteurization on reduction of pathogens, concept and principles of microwave and radio frequency heating, Infra- Red (IR), Ohmic and Inductive heating. Effect of heat on nutritional and sensory characteristics, mechanism of microbial inactivation by thermal processing techniques.

Learning Outcomes:

At the end of this unit, the student will be able to

- Explain the mechanism of MW and RF radiation for food preservation and quality improvements (L2)

	• explain the principles and application heating in food processing (L2) • Explain principles and applications of Pulse electric field (PEF) in food processing (L2) • Explain the principles and applications of X-ray irradiation for food processing (L2)

Unit- III	**6 hrs**

Non-thermal food processing: Concept and principles of non-thermal food processing, Hurdle technology for food preservation and processing Theory, equipment and application of High pressure processing (HP) and ultrasonic processing.

Preservation of foods by pulsed light technology.
Food Irradiation, technology of food irradiation, and effect of irradiation on food borne microbial pathogens. Ionizing Radiation sources. Mechanism of microbial inactivation.

Learning Outcomes:

	After completing this unit, the student will be able to • describe hurdle technology for food (L1) • describe principles and applications of High Pressure Processing (HPP) (L1) • describe principles and applications of ultrasonic processing (L1) • describe principles and applications of nanotechnology in food processing (L1)

Unit- IV	**6 hrs**

Food safety and good manufacturing practice, , Contaminants and Food Safety, Quality controls and its detection in foods products: Methods of quality assessment, Export Quality Control and Inspection Systems, Concept and application of Codex Alimentarious, HACCP, and ISO 9000; Package principles, Controlled-or-modified-atmosphere storage and packaging, Deteriorative changes in foodstuff in packed food, Packaging methods for protection from deterioration, Approaches for enhancing. Shelf life of packaged foodstuff.

Learning Outcomes:

	After completing this unit, the student will be able to • Describe methods for quality assessment of foods (L1) • Describe standards for food quality (L1) • Describe role of packaging (L1) • Describe the mechanism of food spoilage (L1) • Describe methods to extend shelf life of food products (L1)

Unit- V	**6 hrs**

Nutraceuticals and functional foods: Definition, Classification of nutraceuticals, health benefits of nutraceuticals, Spirulina, Ginseng , Lycopene, Microbes as nutraceuticals, Probiotics, Prebiotics. Functional foods, Different cereal products.

Learning Outcomes:

	After completing this unit, the student will be able to • Describe the role of nutraceutical compound/ food (L1) • Describe the mechanism of action of nutraceuticals (L1) • Describe the manufacturing methods of nutraceutical (L1) • distinguish probiotics and prebiotics food (L3)
Course Outcomes:	
	After the completion of the course the student should be able to • understand the scope and importance of food processing. (L2) • understand the application of membrane technology (L2) • design the filter module for long stability of filtration process (L5) • formulate food products based on modern customer demand. (L3) • understand the benefits of nutraceuticals (L2)
Text Books:	
	1. Zeki Berk, 2009, Food Process Engineering and Technology, International Series. Series Editor: Steve L. Taylor, First edition, 2. P. Fellows, 2000, Food Processing Technology: Principles and Practice, Woodhead Publishing Limited, Cambridge CB1 6AH, England 3. Carl J Schaschke, 2011, Food Processing, Carl J. Schaschke & Ventus Publishing ApS
References:	
	1. Fellows, P. & Ellis H.1990 Food Processing Technology. Principles and practice; Newyork 2. Macrae R, Roloson R & Sadlu MJ. 1994. Encyclopedia of Food Science & Technology & Nutrition. VolXVI. Academic Press. 3. Nesser JR & German BJ.2004. Bioprocesses and Biotechnology for Nutraceuticals. Chapman & Hall. 4. Shi J. (Ed) 2006. Functional Food Ingredients and Nutraceuticals: Processing Technologies. CRC. 5. Barbosa-Canovas, G.V.,Maria Tapia and M. Pilar Cano, eds. 2005. Novel Food processing Technologies. Boca Raton, FL: CRC Press. 6. Rajesh K. Srivastava, Food processing, quality analysis and quality assurance, 2018, Shree publishers and contributions, Delhi 7. Perkins Muredzi, 2013, Food is Medicine – An Introduction to Nutraceuticals, LAP LAMBERT Academic Publishing, pp.276

FOOD PROCESSING TECHNOLOGY LABORATORY

Minimum of 8 experiments from the following:

Experiment- 1-: Crude Protein- Kjeldahl Method

Experiment- 2-: Moisture Content- Lab Oven Method

Experiment-3-: Crude Fat- Soxhlet Apparatus Method

Experiment- 4-: Detection of adulterants in different food products

Experiment- 5-: Crude Fiber Objective

Experiment- 6-: Cut out test for Canned Fishery Products

Experiment- 7-: Determination of total carbohydrate of a food sample

Experiment- 8-: Microbiological analysis of fruits and vegetables

Experiment- 9-: Microbial analysis of ice cream and soft drink

Experiment- 10: Good Manufacturing Practices for foods

Experiment- 11: Food Preservation Techniques

Experiment- 12: Control drying of fruits and vegetable by microwave heating.

Objective 1: To find out the amount of crude protein in a given food sample

Objective 2: To find out the moisture content from a given food sample by lab oven method

Objective 3: To find out the amount of crude fat in a given food sample.

Objective 4- To test different given food samples for adulteration

Objective 5- To find out the amount of crude fiber in a given food sample

Text Book(s)

1. S. Ranganna, Handbook of analysis and quality control for fruit and vegetable products, 2/e, Tata McGraw Hill, 1986.

2. S. S. Nielsen, Introduction to the chemical analysis of foods. CBS Publishers and Distributors, 2002.

SEA AND DAIRY FOOD PROCESSING

The sea and dairy food are major components of the food processing industry with specialized requirements. This course describes the methods used for food processing and food quality assessment applicable to sea and dairy foods.

Course Objectives:

- Describe the scope and importance of sea and dairy food processing. (L2)
- describe milk processing technology (L1)
- introduce unit operations in sea and dairy food processing (L3)
- describe the processing technology for production of butter and cheese (L1)
- describe the regulations pertinent to the sea and dairy food industries

Unit- I	**6 hrs**

Seafood Processing: Principles of preservation and processing ; chilling and freezing methods, cold storage, phenomena of rigor mortis, spoilage changes and causative factors. Drying; conventional methods, salt curing, pickling and smoking. Canning and hurdle technology in food preservation. Role of preservatives in processing. Fishery by-products.

Learning Outcomes:

After completing this unit, the student will be able to

- Apply the principles of preservation (L3)
- Select a method for preservation based on scientific principles (L3)
- Describe the methods of preservation (L1)

Unit- II	**6 hrs**

Milk processing: Fluid milk processing, packaging and distribution. Common dairy processes: cream separation (standardization), pasteurization, sterilization and homogenisation. UHT processing of milk. Process technology for manufacture of evaporated milk, condensed milk, dried milk, malted milk, reconstituted/rehydrated milk, recombined milk, toned milk and fermented milk.

Learning Outcomes:

After completing this unit, the student will be able to

- List milk products (L1)
- Select the optimum method for preservation of milk (L3)
- Describe the methods of milk processing (L1)

Unit- III	**6 hrs**

Dairy and food processing operations 1: Overview of thermal operations carried out in dairy processing. Role of water and water activity in foods. Crystallization and freezing. Estimation of freezing time of foods. Concentration of liquid foods in batch, continuous type and multiple effect evaporators with mechanical and thermal vapour compression. Mechanism of moisture removal in solid and liquid foods during drying. Spray, freeze, roller tray and through-flow drying operations.

Learning Outcomes:

After completing this unit, the student will be able to

- Estimate freezing time of food materials (L3)
- Describe the methods of moisture removal (L1)
- Select the optimum method for removal of moisture (L3)

Unit- IV	**6 hrs**

Dairy and food processing operations 2: Overview of mechanical operations carried out in dairy processing. Particle size separation in spray dryer and gravity separator. Filtration of food. Slurry filter medium and cake resistances. Size separation through sieving. Particle movement in sediment and centrifugal settling tank. Solid bowl and disc bowl centrifuges. Operation of cyclone separator and self cleaning centrifuge. Agitation and mixing of liquid foods, powders and pastes.

Learning Outcomes:

After completing this unit, the student will be able to

- Describe the principles of particle size separation (L1)
- Describe the mechanical methods used food processing (L1)
- Select the optimum method for size separation (L3)

Unit- V	**6 hrs**

Butter: Composition, flow diagram of production, yield, fat loss in butter making. Continuous butter making, grading of table butter, defects in butter; causes and prevention. Cheese: Flow diagram of production. Cheddar cheese, mozzarella cheese and processed cheese manufacturing. Curing and storage of cheese. Defects causes, prevention and quality control. Ice Cream: Composition and flow diagram of production. Infant, baby foods and indigenous dairy products. Laws and standards in Fishery Industry: Quality control with reference to sea food. Novel product development, nutrition promotion, consumer studies, marketing and sea food export. MPEDA, government policies, export finance, economic importance.

Learning Outcomes:

After completing this unit, the student will be able to

- Describe the production of butter (L1)
- Describe the production of cheese (L1)
- Select the optimum method for novel product development (L3)

Course Outcomes:

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

- understand the scope and importance of sea and dairy food processing. (L2)
- understand the application of milk processing technology (L2)
- optimize unit operations in sea and dairy food processing (L3)
- describe the processing technology for production of butter and cheese (L1)
- describe the regulations pertinent to the sea and dairy food industries (L1)

Text Books:

1. A. Tufail, Dairy Plant Engineering and Management, Kitab Mahal Distributors, 2014.

2. P. Sinha, Fish processing and preservation, APH Publishing, 2011.

References:

1. A.W. Farrall, Engineering for Dairy and Food Products, John Wiley and Sons, New York, 1963.

2. R. P. Aneja, B. N. Mathur, R. C. Chandan and A. K. Banerjee, Technology of Indian Milk Products: Handbook on Process Technology, Modernization for Professionals, Entrepreneurs and Scientists. A Dairy India Publication, 2002.

SEA AND DAIRY FOOD PROCESSING LABORATORY

Minimum of 8 experiments from the following:

1. Drying of fish
2. Production of marine algal foods
3. Production of cheese
4. Production of yoghurt
5. Production of buttermilk
6. Production of butter
7. Evaluation of cheese
8. Evaluation of yoghurt
9. Pasteurization of milk
10. Evaluation of milk

Text Book(s)

1. S. S. Nielsen, Introduction to the chemical analysis of foods. CBS Publishers and Distributors, 2002.

Biophysics

Course Code	Course Title	L	T	P	J	S	C
XXXXXXXX	Biophysics	3	0	0	0	0	3
Course Owner	Biotechnology	Syllabus version				1.0	
Course Pre-requisite(s)		Contact hours				45	
Course Co-requisite(s)	None	Date Approved				-	
Alternate Exposure	Coursera Courses						

Biological organisms utilize energy from external sources to drive non-equilibrium processes that are utilized for the benefit of the organism and its progeny. Biophysical models can be used to explain the interactions of forces, fields and biological molecules that produce complex behaviour in biological systems. Noninvasive biophysical imaging methods can provide detailed structural information that is useful for diagnosis and quality control. This course introduces the biophysical principles and methods useful for understanding the structure and function of biological organisms.

Course Objectives

- Explain the physics of energy transfer and molecular interactions in biological systems
- Explain the physical basis of human vision and hearing
- Describe the physiology of biological information processing and response
- Explain the mechanics of locomotion
- Describe the methods for biomedical imaging

Unit 1 Bioenergetics No of Hours : 10

Energy transfer mechanisms. Photophysics of chlorophylls and carotenoids: MO model for the electronic states. Huckel approximation. Energy transfer in photosynthetic systems. Role of electron transfer in biological systems. Mechanisms of electron transfer. Proton transfer in bacteriorhodopsin. Molecular basis of human photoreception and Mechano-electrical transduction.

Learning Outcomes

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

- Understand the electronic structure of chlorophyll and carotenoids (L2)
- Apply Huckels MO theory to explain properties of carotenoids (L3)
- Compare energy transfer mechanisms in photosynthetic systems (L5)
- Describe proton transfer in bacteriorhodopsin (L1)
- Explain the mechanism of vision and auditory sensing (L4)

Pedagogy tools:

Self-reading , Lecture

Unit 2 Molecular biophysics No of Hours : 10

Introduction to molecular mechanics. Role of hydrogen bond in biological systems. Models of allosteric interactions. Thermal stability of double stranded DNA. Transport of oxygen in humans. Self assembly of micelles and lipid bilayers. Membrane potential. Measurement of transmembrane ionic current. Transmembrane transport mechanisms.

Learning Outcomes

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

- Understand the forces directing the interaction of biological molecules (L1)
- Analyze the physics of self-assembly and stability of multicomponent molecular systems (L1)
- Compare models for ion transport through a membrane (L1)

Pedagogy tools:

Self-reading , Lecture

Unit 3 Neurobiophysics No of Hours : 8

Conduction of an action potential. Transmission of a nerve impulse across a synapse. Molecular mechanism of memory formation. Experimental measurement of brain activity. Mechanism of activation of muscles by nerve signals. Introduction to cybernetics and coordinated control of movement.

Learning Outcomes

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

- Explain mechanism of nerve impulse conduction and transmission (L4)
- Describe the mechanism of memory formation (L1)
- List experimental methods for measurement of brain activity (L1)
- Describe mechanism of activation of muscles and coordinate control of movement (L1)

Pedagogy tools:

Self-reading , Lecture

Unit 4 Biomechanics No of Hours : 9

Molecular motor models. Measurement of force generated by molecular motors. Propulsion by cilia and flagella. Models of Bacterial chemotaxis. Biofluid mechanics. Scaling laws applicable to biomechanics of locomotion. Energetic cost of locomotion. Terrestrial locomotion gaits. Froude number and dynamic similarity.

Learning Outcomes

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

- Explain the mechanism of action of molecular motors (L4)
- Describe methods for measurement of force generated by molecular motors (L1)
- Differentiate between ciliary and flagellar motion (L4)
- Apply the scaling laws of biomechanics of locomotion (L3)
- Describe the biomechanics of terrestrial locomotion (L1)

Pedagogy tools:

Self-reading , Lecture

Unit 5 Biomedical imaging No of Hours : 8

Principles of following non-invasive imaging techniques: CT, PET, ultrasonography and MRI. Application of magnetic resonance for non-invasive imaging. Encoding of spatial information by using magnetic field gradients. MRI for non-invasive pharmacokinetic studies and medical diagnostics. Superparamagnetic iron oxide nanoparticles and their theranostic applications.

Learning Outcomes

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

- Understand the principles of common non-invasive imaging techniques
- Describe applications of MRI (L1)
- Explain the principles of MRI (L4)
- Explain relationship between properties of SPIONS and their theranostic applications (L4)

Pedagogy tools:

Self-reading , Lecture

Texbook(s)

1. W. Hoppe, W. Lohmann, H. Markl, H. Ziegler. Biophysics. Springer. 2012.
2. Andrew W Wood. Physiology, Biophysics, and Biomedical Engineering. CRC Press. 2012.

Additional Reading(s)

1. Andrew A. Biewener and Sheila Patek. Animal Locomotion. 2nd Edition. OUP Oxford, 2018.
2. Susan Hall. Basic biomechanics. 8th edition. McGraw Hill. 2019.
3. Robert W. Brown, Y.-C. Norman Cheng, E. Mark Haacke, Norman Cheng, Michael R. Thompson, Ramesh Venkatesan. Magnetic Resonance Imaging: Physical Principles and Sequence Design. John Wiley & Sons, 2014

Journal(s)

1. K J Breslauer, R Frank, H Blöcker, and L A Marky, PNAS June 1, 1986 83 (11) 3746-3750,Unit-2
2. Journal of Neurochemistry, 2006, 97, 1520–1533. Barco, Bailey and Kandel
3. Wadhams, G., Armitage, J. Making sense of it all: bacterial chemotaxis. Nat Rev Mol Cell Biol 5, 1024–1037 (2004)

Website(s)

NPTEL: Physics of Biological Systems

Course Outcomes:

1. Describe models of energy transfer in photosynthesis (L1)
2. Analyze the control systems and mechanics of motion in biological systems (L1)
3. Apply scaling laws for biological locomotion (L4)
4. Calculate energy requirements for motion in biological systems (L4)
5. Compare the advantages and disadvantages of biomedical imaging techniques (L4)

	POs												PSOs		
CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	3	3									1	
2	3	3	3	3	3									1	
3	3	3	3	3	3									1	
4	3	3	3	3	3									1	
5	3	3	3	3	3									3	1
Avg	3.0	3.0	3.0	3.0	3.0									1.4	1.0

1-Low, 2- Medium and 3- High Correlation

FOOD HANDLING, PACKAGING AND STORAGE

Course Objectives:

- Acquire knowledge of various type of material handling and the type of equipment utilized
- Understand to designing food packaging materials depends the variety of food products
- Select the packaging materials and types depending upon the properties and sources of food.
- ensure the self-life of the packaged food product and adapt appropriate storage condition
- Describe the national and international acts and rules about food packaging

Unit- I :	**9 hrs**

Material Handling: Solids and granular materials handling: elevators, conveyors; Pumps: centrifugal and positive displacement; Liquid filling machines: open vent, closed vent and piston fillers.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understanding the physical properties of materials
- Basic operational principles of various machinery used to process materials

Unit- II:	**9 hrs**

Packaging Materials: Polymer films, metal containers, flexible packages, special packing.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understanding of different types of packaging material and its properties
- Designing different type of modern packaging and concept of packaging system

Unit- III	**9 hrs**

Food Packaging: Requirements for cereals, meat, poultry, fish, milk, vegetables, fruits, plantation crop based products and carbonated beverages.

Learning Outcomes:

After completing this unit, the student will be able to

- Selection of food packaging materials for different types of food product
- Source of food product and it properties of processed and unprocessed food product

Unit- IV	9 hrs
Storage Principle and Practice: Storage losses and their estimation: Modified and control atmosphere storage: Bin and silo storage for cereals and pulses.	
Learning Outcomes:	
	After completing this unit, the student will be able to • To understanding the appropriate storage condition for processed and unprocessed food product • To minimize the food wastage • To facilitate the incoming and outgoing food product from warehouse
Unit- V	**9 hrs**
Loss in cereal quality: insect and pest control. Design of storage structures and facilities including cold storage.	
Learning Outcomes:	
	After completing this unit, the student will be able to • To understanding long term stored and seasonal food product storage and enhance the shelf life of product • To understanding pest and rodent control
Course Outcomes:	
	After the completion of the course the student should be able to • Designing various food packaging materials and the equipment's used in processing of materials • Select the packaging materials based on their properties and usage. • Apply principles of food processing for efficient packaging with enhanced self-life with implementation of various acts and rules • Specialised and sustainable (environmentally) packaging for end user satisfaction.
Text Books:	
	1.M.J. Kirwan, McDowell, R.Coles, Food packaging technology. Wiley- Blackwell, 2010.
References:	
	1. S. Stanley, C.G. Roger, Food Packaging, AVI Publications, 1970. 2. S. Sacharow, R.C. Griffin, Principles of Food Packaging, AVI Publication, 1980. 3. F.A. Painy, A handbook of Food Packaging, App. Sci. Publishers, 1980.

FOOD SAFETY AND QUALITY MANAGEMENT

In our healthy life, selection of types of foods or its products play important role with awareness of types of foods. And modern era, our customers are more sincere about selection of foods which could be safe, nutritious and least processed in nature. Most of our food processing industries are developing the more variety of foods for our people. But they are sensitive about processing conditions with maintenance of food standards as well ensuring of food safety for their products. A lot of international or national food safety guideline has been provided to maintain our products in safety nature.

Course Objectives:

- To understand the values of hygienic conditions for our food products
- To understand the guidelines for food safety issues to be maintained
- To understand the food borne disease from food safety failure
- To understand the food processing condition changes during transformation of foods
- To optimize processing conditions for more safe food products

Unit- I	**9 hrs**

Characterization of food safety: Food Safety definition and principles, characterization of food hazards, risk analysis for chemical and microbial hazards, exposure assessment of microbial food hazards, chemical risk assessment in foods

Learning Outcomes:

At the end of this unit, the student will be able to

- Students will learn the food safety guideline during food processing
- Students will learn the different types of hazarding agents, occurred during food handling or processing
- Students will learn the different risk assessment for food safety maintenance during food processing
- Student will understand the different hazard agents effecting the food safety

Unit- II	**9 hrs**

Food hazards from biological agents, prevalence of food-borne pathogens, physiology and survival of food-borne pathogens in various food systems, characteristics of biological hazards in foods

Learning Outcomes:

At the end of this unit, the student will be able to

- Students will learn biological agents (microbial or macro-organism), causes food hazards during food handling, transporting or processing
- Students will learn the different factors for inducing the biological mediated food hazards occurred during food handling or processing

	• Students will learn for characterization methods of biological risk assessment for food safety • Student will understand impact of biological food hazard with their food quality

Unit- III	**9 hrs**
Chemical and physical nature of food hazards, hazards from natural origins, chemical and physical hazards produced during food processing, storage, and preparation, hazards associated with nutrient fortification, monitoring chemical hazards: regulatory information	
Learning Outcomes:	

	After completing this unit, the student will be able to • Students will learn physical or chemical nature agents, causes food hazards during food handling, transporting or processing • Students will learn about hazards impact from natural origins food safety issues occurred during food handling or processing • Students will learn for fortification of food with food safety and also learn for monitoring strategy for assessment of hazards nature • Student will understand food hazard nature with their neutralization mechanisms

Unit- IV	**9 hrs**
Food quality and food standard, Codex Alimentarius as FAO/WHO food standards program Implementation of FSLS regulatory programs for pathogen reduction, advances in food sanitation: use of intervention strategies, use of surveillance networks, hazard analysis critical control point (HACCP)	
Learning Outcomes:	

	After completing this unit, the student will be able to • Students will learn food standard to ensure the food quality with safe food products • Students will know about different guideline for maintaining the food safety at national or international levels • Students will learn food safety assessment via utilization of regulatory guideline during food processing • Student will understand the different mechanism to control the food hazards during post harvesting periods

Unit- V	**9 hrs**
Food plant sanitation, food safety control systems in food processing, food safety and innovative food packaging, safe handling of fresh-cut produce and salads, good manufacturing practices, prerequisites for food safety, the principles of modern food hygiene	

Learning Outcomes:	
	After completing this unit, the student will be able to • Students will learn food sanitation guideline to ensure food safety • Students will know innovative and safe handling of food products • Students will learn good manufacturing practicing for food safety • Student will understand mechanism good and modern food hygiene principles
Course Outcomes:	
	After the completion of the course the student should be able to • People can purchase of more variety of food via ensuring the food safety issues • Processed foods can create more marketing opportunity for different food once consumer will secure about food safety issue and quality or food standards • Safe food can enhance the shelf-life of many foods • Processed foods can help to gain more opportunity for investment with foreign currency gain with proving of food safety and hygienic processing conditions • Processed foods can maintain the sensory quality and nutrient contents for customers for long periods
Text Books:	
	1.Ronald H. Schmidt and Gary E. Rodrick, 2003, Food Safety Handbook. A John Wiley & Sons Publication
References:	
	1.A. K. Singh P. N. Raju & A. Jana. Food Technology-I, www.agrimoon.com 2.R. Paul Singh and Dennis R. Heldman. 2009. Introduction to Food Engineering Fourth Edition, Academic Press is an imprint of Elsevier

MARINE BIOTECHNOLOGY

Marine ecosystems are a major source of food, oxygen and play a vital role in biogeochemical cycles. This course describes the natural products obtainable from marine resources and the application of biotechnology for diagnosis of diseases prevalent in commercially important marine organisms such as fish.	
Course Objectives:	
	Introduce the marine environment and the processes associated. • Provide the basis for evaluation and conservation of marine biodiversity. • Describe the resources from marine environment. • Introduce the different aspects of aquaculture. • Describe the applications of marine biotechnology
Unit- I	**9 hrs**
Overview of the present status of marine biotechnology, Marine ecosystems – intertidal zone, inhabitants and ecology of estuaries, salt marshes, mangrove swamps, coral reefs and the deep sea, Plankton, nekton and benthos.	
Learning Outcomes:	
	At the end of this unit, the student will be able to • summarize the status of marine biotechnology in India(L2) • distinguish different zones in the marine environment(L4) • classify marine organisms. (L2)
Unit- II	**9 hrs**
Introduction to tides and waves. Water currents and winds. Major and minor elements in the sea water and their importance, dissolved oxygen. Biogeochemical cycles (Carbon, Nitrogen, Sulphur and Phosphorus) in the ocean. Global climatic change and potential effects on coral bleaching, eutrophication.	
Learning Outcomes:	
	At the end of this unit, the student will be able to • the importance of physical and chemical processes in the marine environment(L2) • explain global climate changes(L2) • interpret the effects of climate change in the marine environment(L2)
Unit- III	**9 hrs**
Applications from both the biology and policy perspectives (e.g. endangered species, captive breeding, habitat fragmentation, ecosystem restoration, rehabilitation. Marine food web dynamics - primary, secondary and tertiary production.	

Learning Outcomes:

After completing this unit, the student will be able to

- evaluate marine biodiversity (L5)
- explain the methods of conservation of marine environment as well as organisms(L2)
- Percieve the potential of marine food web.(L5)

Unit- IV	**9 hrs**

Marine natural products, aquaculture, valuable chemicals, bioactive compounds from micro-algae, macro-algae and other marine organisms.Important enzymes from marine microorganisms and their applications: Xylanases, proteases, chitinases.

Learning Outcomes:

After completing this unit, the student will be able to

- appraise the potential of marine organisms in terms of natural products(L5)
- identify chemicals and bioactive compounds useful in medical and research applications(L3)
- explain the importance of enzymes for industrial applications(L2)

Unit- V	**9 hrs**

Marine biotechnology for economic development and environmental problem solving. Aquaculture- fish, shrimp and pearl oyster culture. Transgenic marine organisms. Biofouling and prevention. Bioremediation. Probiotic bacteria and their importance in aquaculture. PCR, molecular and immunological techniques for determination and identification of bacterial and viral pathogens in aquaculture. Vaccines for aquaculture.

Learning Outcomes:

After completing this unit, the student will be able to

- Explain the potential of marine biotechnology for economic development & to resolve environmental issues(L5)
- outline the principles & processes of different aquaculture techniques(L2)
- summarize the use of biotechnological approaches to develop transgenic marine animals and maintenance of health of cultured organisms. (L2)

Course Outcomes:

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

- explain physicochemical aspects of marine environment(L5)
- summarize applications of marine natural products(L2)
- apply biotechnological interventions to economic and environmental issues(L3)

	• appreciate the importance of marine biotechnology. (L5)
Text Books:	
	1. Text book of Marine Ecology.(1989). Nair N.B. & Thampy, D.M. 2. Recent Advances in Marine Biotechnology. Vol.2 (1998) Fingerman, M., Nagabushanam, R., Thompson, M.
References:	
	1. Biological Oceanography.(1999). Lilly, C.M. 2. Ecology of Coastal water.(1988). Mann, K.H. 3. An introduction to Marine Sciences.(1988). Meadows, P.S. & Campbell J.J. 4. General Oceanography–An introduction (1980). Dietrich,G., Kalle,K, Krauss,W&Siedler, G. 5. Biotechnology in the marine sciences: Proceedings of the first annual MIT Sea grant lecture & seminar. (1984). Colwell, R.D.(Ed)

PHARMACEUTICAL BIOTECHNOLOGY

The science of Pharmaceutical biotechnology is a dynamic science aims at focusing the attention of students at the manufacture and recovery of biopharmaceuticals and other biological products, basic knowledge about biological techniques used in production some of biological drugs and some basic principles and definitions related to Pharmaceutical biotechnology. Dosage forms, pharmacokinetics, dynamics and Clinical Trials,case studies on biopharmaceutical product development which would broaden the knowedge-base of the students.

Course Objectives:

- Introduce the drug discovery, development regulatory aspects of drugs and cosmetics act.
- Impart knowledge of drug dosage forms Pharmacokinetics and dynamics.
- Summarize drug delivery methods.
- Explain pharmacology principles, classification of drugs and mechanism.
- Discuss case studies on biopharmaceutical product development

Unit- I : Introduction	**9 hrs**

History of pharmaceutical industry, Drugs discovery and Development phases; Drugs and Cosmetics Act and regulatory aspects; Definition: Generics and its advantages; Biogenerics and Biosimilars; The role of patents in the drug industry; Protein-based biopharmaceuticals.

Learning Outcomes:

At the end of this unit, the student will be able to

- explain history of pharmaceutical industry (L2).
- explain drug discovery and development phases (L2).
- outline the regulatory aspects, drugs and cosmetics Act (L1).
- understand the role of patents in drug industry and protein based drugs (L2).

Unit- II: Dosage form	**9 hrs**

Definition of Dosage forms, Classification of dosage forms (solid unit dosages – Tablets, capsules; liquids – solutions, lotions, suspension etc; semi-solid – ointments; Parenterals), Introduction to pharmacokinetics and pharmacodynamic principles (factors affecting the ADME process).

Learning Outcomes:

At the end of this unit, the student will be able to

- define dosage forms (L2).
- explain different classes of dosage forms (L2).
- introduction to concepts of pharmacokinetics and pharmacodynamic principles (L2).

	• understand the factors affecting ADME (L2).

Unit- III	**9 hrs**
Applications from both the biology and policy perspectives (e.g. endangered species, captive breeding, habitat fragmentation, ecosystem restoration, rehabilitation. Marine food web dynamics - primary, secondary and tertiary production.	
Learning Outcomes:	

	After completing this unit, the student will be able to • evaluate marine biodiversity (L5) • explain the methods of conservation of marine environment as well as organisms(L2) • Percieve the potential of marine food web.(L5)

Unit- IV	**9 hrs**
Marine natural products, aquaculture, valuable chemicals, bioactive compounds from micro-algae, macro-algae and other marine organisms.Important enzymes from marine microorganisms and their applications: Xylanases, proteases, chitinases.	
Learning Outcomes:	

	After completing this unit, the student will be able to • appraise the potential of marine organisms in terms of natural products(L5) • identify chemicals and bioactive compounds useful in medical and research applications(L3) • explain the importance of enzymes for industrial applications(L2)

Unit- V	**9 hrs**
Marine biotechnology for economic development and environmental problem solving. Aquaculture- fish, shrimp and pearl oyster culture. Transgenic marine organisms. Biofouling and prevention. Bioremediation. Probiotic bacteria and their importance in aquaculture. PCR, molecular and immunological techniques for determination and identification of bacterial and viral pathogens in aquaculture. Vaccines for aquaculture.	
Learning Outcomes:	

	After completing this unit, the student will be able to • Explain the potential of marine biotechnology for economic development & to resolve environmental issues(L5) • outline the principles & processes of different aquaculture techniques(L2) • summarize the use of biotechnological approaches to develop transgenic marine animals and maintenance of health of cultured organisms. (L2)
Course Outcomes:	

	After the completion of the course the student should be able to • explain physicochemical aspects of marine environment(L5) • summarize applications of marine natural products(L2) • apply biotechnological interventions to economic and environmental issues(L3) • appreciate the importance of marine biotechnology. (L5)
Text Books:	
	1. Text book of Marine Ecology.(1989). Nair N.B. & Thampy, D.M. 2. Recent Advances in Marine Biotechnology. Vol.2 (1998) Fingerman, M., Nagabushanam, R., Thompson, M.
References:	
	1. Biological Oceanography.(1999). Lilly, C.M. 2. Ecology of Coastal water.(1988). Mann, K.H. 3. An introduction to Marine Sciences.(1988). Meadows, P.S. & Campbell J.J. 4. General Oceanography–An introduction (1980). Dietrich,G., Kalle,K, Krauss,W&Siedler, G. 5. Biotechnology in the marine sciences: Proceedings of the first annual MIT Sea grant lecture & seminar. (1984). Colwell, R.D.(Ed)

ARTIFICIAL NEURAL NETWORKS

Neural Networks can assist in the analysis, interpretation and utilization of large amounts of highly complex structured and unstructured data. Neural Network based decision support systems have been deployed in agricultural, biomedical, biometric, economic and legal applications. Neural Networks can be utilized as components of advanced robots and control systems for industrial automation. Neural Networks can also be utilized in engineering design.

Course Objectives:

- introduce a variety of Neural Network architectures
- evaluate merits and demerits of learning models used by Artificial Neural Networks
- describe the algorithms for training of Neural Networks
- explain the effect of choice of parameters on training efficiency
- exemplify the relation between problem type and Neural Network type

Unit- I :	**6 hrs**

Introduction to Neural Networks: Architecture based classification of Neural Networks. Classification of Neural Networks based on learning methods. Activation functions and Loss functions. Factors to be considered for choice of type of Neural Network. Introduction to hardware requirements for implementation of Neural Networks.

Learning Outcomes:

At the end of this unit, the student will be able to

- classify Neural Networks based on type of architecture (L2)
- classify Neural Networks based on type of learning (L2)
- identify optimal type of Neural Network based on problem description (L4)

Unit- II:	**6 hrs**

Rosenblatt's perceptron model. Rosenblatt's perceptron convergence theorem. Back Propagation Method. Back propagation learning algorithm for multilayer feed forward Neural Network. Factors affecting back propagation based training of a Neural Network.

Learning Outcomes:

At the end of this unit, the student will be able to

- prove convergence for Rosenblatt's perceptron model (L2)
- calculate output of a small feed forward Neural Network with one hidden layer for specified values of architectural parameters and weights using a handheld calculator (L5)
- predict the effect of parameters on training efficiency using the backpropagation learning algorithm (L4)

Unit- III	**6 hrs**

Radial basis function networks. Generalized regularization theory. Neural Network models with Hebbian learning. Introduction to Hopfield networks. Recurrent Neural Network models. Universal approximation theorem. Backpropagation through time. Real time recurrent learning. Long short term memory.		
Learning Outcomes:		
	After completing this unit, the student will be able to • understand concepts of hebbian learning models (L2) • describe recurrent Neural Networks and their applications (L1) • evaluate a problem and identify the optimal training algorithm (L5)	
Unit- IV		**6 hrs**
Convolutional Neural Networks. Variants of the basic convolution function. Convolution algorithms. Recursive Neural Networks. Greedy layer-wise pretraining. Transfer learning. Structured probabilistic models for deep learning. Convolutional boltzmann machines.		
Learning Outcomes:		
	After completing this unit, the student will be able to • identify advantages and disadvantages of deep learning (L2) • describe concepts of convolutional Neural Networks (L1) • compare merits and demerits of deep learning (L4)	
Unit- V		**6 hrs**
Model based calculation of reward in Reinforcement learning. Markov decision process. Bellman's optimality criteria. Policy iteration. Value iteration. Q-learning. Model free Reinforcement learning. Deep reinforcement learning. Generative adversarial networks		
Learning Outcomes:		
	After completing this unit, the student will be able to • understand the concepts of reinforcement learning (L2) • analyze a problem and identify optimal algorithms for its solution (L4) • evaluate reward for specified model and policy function for training a Neural Network by using reinforcement learning (L5)	
Course Outcomes:		
	After completing this unit, the student will be able to: • describe different types of artificial neural networks (L1) • justify the back propagation algorithm (L2) • understand different types of learning mechanisms (L1) • understand the principles of deep learning and convolutional neural networks (L2) • understand the principles of reinforcement learning (L1)	

ARTIFICIAL NEURAL NETWORKS LABORATORY

At least five of the following experiments:

1. Software installation for Artificial Neural Networks
2. Training of an Artificial Neural Network
3. Testing of a trained Artificial Neural Network
4. Application of an Artificial Neural Network for secondary structure prediction
5. Application of an Artificial Neural Network for protein-ligand binding study
6. Application of an Artificial Neural Network for promoter identification
7. Application of an Artificial Neural Network for identification of genes in a genome
8. Application of an Artificial Neural Network for image recognition

BIOPROCESS PLANT DESIGN

Unit- I	**6 hrs**
General design information; Material and energy balance calculations; Process flowsheeting.	
Unit- II	**6 hrs**
Scale up issues: Effect of oxygenation, mixing, sterilization, pH, temperature, inoculums and nutrient availability; Bioreactor scale-up based on constant power consumption per unit volume, mixing time, impeller tip speed (shear), mass transfer coefficients. Scale up of downstream processes: Adsorption (LUB method); Chromatography (constant resolution); Filtration (constant resistance); Centrifugation (equivalent times); Extractors (geometry based rules).	
Unit- III	**6 hrs**
Selection of bioprocess equipment (upstream and downstream); Specifications and Mechanical design of reactors, heat transfer and mass transfer equipment; Design considerations for maintaining sterility of process streams and process equipment.	
Unit- IV	**6 hrs**
Facility design: Utility supply; Equipment cleaning; Cell culture banks; cGMP guidelines; Validation; Safety.	
Unit- V	**6 hrs**
Pilot plant design; Fermenter design calculations (simulations), downstream processing calculations, environmental and economic considerations.	

Course Outcomes:

At the end of the course, students are able to

- apply engineering principles to design unit operations in bioprocess plant.
- design and evaluate a suitable unit operation and equipment in a bioprocess plant.
- apply modern simulation software to solve unit operations.
- design process flow diagram (PFD) for bioprocess plant.

Text Books:

1. M.V. Joshi and V.V. Mahajani, Process Equipment Design, 3/e, Macmillan India, 2008.
2. J.M. Coulson, J.F. Richardson (Eds.) and R.K. Sinnott, Chemical Engineering Volume 6: An introduction to Chemical Engineering Design, 2/e, Butterworth-Heinemann, 1996.

References:

	1. M. Shuler and F. Kargi, Bioprocess Engineering Basic Concepts, 2 /e, Prentice Hall, 2002. 2. M. S. Peters and K. D. Timmerhaus, Plant Design and Economics for Chemical Engineers, 3/e, McGrawHill, 2003. 3.R. H. Perry and D. W. Green (eds.), Perry's Chemical Engineers' Handbook, 8/e, McGraw Hill, 2007.

Learning Outcomes

Unit- I

At the end of the unit, students are able to

Understand the design concepts
Perform the material balance calculations
Perform energy balance calculations
Draw process flow sheet
Incorporate material and energy balances into the process flow sheet

Unit- II

At the end of the unit, students are able to

Understand the requirements for bioprocess design
Know the factors required for scaleup
Perform the scaleup of bioreactors from lab to commercial scale
Perform the scaleup of absorption equipment
scaleup the downstream equipment from lab to commercial scale

Unit- III

At the end of the unit, students are able to

Understand the specifications required for bioprocess equipment
Select the equipment for bioprocess design
Design the mechanical aspects of bioreactors
Incorporate the sterility requirements into the equipment
Follow SIP practices in bioprocess plant design

Unit- IV

At the end of the unit, students are able to

Understand the various utilities required for the design of bioprocess Plant
Select the method of cleaning for bioprocess equipment
Operate and maintain the cell culture banks
validate the bioprocess equipment
Follow CIP practices in bioprocess plant design

Unit- V

At the end of the unit, students are able to

Understand the design of pilot plant

Calculate the fermenter design calculations
Calculate the downstream equipment design calculations
Consider environmental aspects into bioprocess plant design
Consider economic aspects into bioprocess plant design

BIOPROCESS PLANT DESIGN LABORATORY

Minimum of 8 experiments from the following:

1. Selection of equipment for production of alcohol by fermentation
2. Plant layout for production of alcohol by fermentation
3. Process flowsheet for production of alcohol by fermentation
4. Material & Energy balance for production of alcohol by fermentation
5. Material and Energy balance for distillation
6. Design of a unit for distillation of alcohol
7. Material and Energy balance for pasteurization of milk
8. Selection of equipment for pasteurization and packaging of milk
9. Design of a unit for pasteurization of milk
10. Plant layout for pasteurization and packaging of milk

Machine Learning in Biotechnology

Course Code	Course Title	L	T	P	J	S	C
XXXXXXXX	**Machine Learning in Biotechnology**	2	0	2	0	0	3
Course Owner	Biotechnology	Syllabus version				1.0	
Course Pre-requisite(s)		Contact hours				45	
Course Co-requisite(s)	None	Date Approved				-	
Alternate Exposure	Coursera Courses						

Machine Learning can assist in the analysis, interpretation and utilization of large amounts of highly complex structured and unstructured data.

Course Objectives:

The objectives of this course are to:

- introduce a variety of machine learning methods
- evaluate merits and demerits of machine learning models
- describe the algorithms for machine learning
- explain the effect of choice of parameters on efficiency of machine learning
- exemplify the relation between problem type and machine learning methodology

Unit I

Introduction to Machine Learning: Definition of learning. Representation and prior knowledge. Types of learning. Logical formulation of learning. Knowledge in learning. Explanation based learning. Learning using relevance information. Inductive logic programming.

Learning outcomes:

At the end of this Unit the student should be able to:

- understand the concept of machine learning (L1)
- classify machine learning methods (L2)
- apply concepts of machine learning (L3)

Unit II

Learning decision trees. Decision tree representation. Inducing decision trees from examples. Evaluating and choosing the best hypothesis. Model selection. Regularization.

Learning outcomes:

At the end of this Unit the student should be able to:

- understand the concept of decision trees (L1)
- understand concepts of model selection (L1)
- evaluate a hypothesis (L5)

Unit III

Learning association, classification and regression. Nonparametric models. Nearest neighbor models. Find nearest neighbors with k-d trees. Nonparametric regression. Principal component analysis. Support vector machines. Unsupervised clustering. Self organizingmaps.

Learning outcomes:

At the end of this Unit the student should be able to:

- understand the concepts of association, classification and regression (L1)
- understand concepts of nearest neighbor models (L1)
- understand concepts of unsupervised learning (L1)

Unit IV

Statistical learning. Maximum likelihood parameter learning. Naive Bayes models. Bayesian parameter learning. Learning with hidden variables. The expectation-maximization algorithm. Learning Hidden Markov Models.

Learning outcomes:

At the end of this Unit the student should be able to:

- understand the concepts of statistical learning (L2)
- understand concepts of naive Bayes models (L2)
- understand concepts of expectation-maximization methods (L2)

Unit V

Probabilistic models of evolution. Machine learning methods for gene finding. Machine learning methods for gene function prediction. Hidden Markov Models of protein sequence families.

Learning outcomes:

At the end of this Unit the student should be able to:

- describe probabilistic models of evolution (L1)
- apply machine learning methods for gene finding (L3)
- analyze protein sequences using Hidden Markov Models (L4)

Course outcomes:

At the end of this course the student should be able to:

- describe major types of machine learning methods (L1)
- classify available machine learning methods (L2)
- apply machine learning to solve simple problems (L3)
- analyze a problem and identify optimal machine learning for its solution (L4)
- evaluate a problem description and predict optimal parameters for its solution (L5)

Text Book(s)

1. P.Baldi, S.Brunak, F.Bach. Bioinformatics: The Machine Learning Approach. 2001. MIT Press.
2. E. Alpaydin. Introduction to Machine Learning. 3Rd edition. 2014. MIT Press.

References

1. S.J.Russell and P. Norvig. Artificial Intelligence: A Modern Approach. 3rd Ed. Pearson. 2016.
2. S.O.Haykin. Neural Networks & Learning Machines. 3rd Ed. Pearson. 2019

	POs												PSOs		
CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	3	3									1	
2	3	3	3	3	3								1	1	
3	3	3	3	3	3									1	
4	3	3	3	3	3									1	
5	3	3	3	3	3									3	1
Avg	3.0	3.0	3.0	3.0	3.0								1.0	1.4	1.0

1-Low, 2- Medium and 3- High Correlation

MACHINE LEARNING IN BIOTECHNOLOGY LABORATORY

At least five of the following experiments:

1. Software installation for Machine Learning
2. Regression analysis for studies of chemical activity
3. Application of Principal Component Analysis for drug activity studies
4. Application of Support Vector Machines for classification of coding & non-coding sequences
5. Application of clustering for classification of gene sequences
6. Application of Hidden Markov Models for sequence analysis

METABOLOMICS AND METABOLIC ENGINEERING

Metabolomic studies are used to characterize the complete set of metabolites in a cell, tissue, organ or organism. Comparative metabolomic studies are useful for identification of biomarkers for diagnostic applications, for elucidation of metabolic pathways and to identify targets for drug design. Metabolic engineering can be utilized for optimizing the yield of desired metabolites in industrial biotechnology. This course introduces the methods for characterization of the metabolome and the methods and applications of metabolic engineering.

Course Objectives:

- Provide information regarding databases of metabolomic data
- Describe methods useful for obtaining metabolomic data
- Introduce methods for analysis of metabolomic data
- Describe the principles of metabolic engineering
- Describe the applications of metabolic engineering

Unit- I	**6 hrs**

Introduction to metabolomics. Metabolite identification and quantification by mass spectrometry and NMR spectroscopy. Mass spectral databases. Metabolic flux determination by time dependent changes in concentration. Metabolic flux determination by isotope labeling: Analysis of mass spectral data. Analysis of NMR spectral data.

Learning Outcomes:

At the end of this unit, the student will be able to

- describe methods for metabolite identification (L1)
- compare methods for metabolite quantification (L3)
- describe methods for metabolic flux determination (L1)
- interpret metabolomic data (L2)

Unit- II	**8 hrs**

Stoichiometry of cellular reactions, mathematical formulation of rate laws. Metabolic network reconstruction. Introduction to Metabolic flux analysis. Steady state analysis and sensitivity analysis (Linear systems only).

Learning Outcomes:

At the end of this unit, the student will be able to

- calculate stoichiometric coefficients (L3)
- explain the concepts of metabolic flux analysis (L4)
- analyze metabolic flux analysis data (L4)
- describe the methods for metabolic network reconstruction (L1)

Unit- III	6 hrs
Metabolic control analysis: Fundamentals of metabolic control analysis, control coefficients and the summation theorems, determination of flux control coefficients. MCA of linear and branched pathways. Case studies.	
Learning Outcomes:	
	After completing this unit, the student will be able to • understand the concepts of Metabolic control analysis (L2) • describe methods for determination of flux control coefficients (L1) • analyze linear and branched pathways (L4)
Unit- IV	**6 hrs**
Metabolic engineering and metabolic pathway engineering. Regulation of metabolic pathways. Regulation of metabolic networks. Metabolic engineering by gene amplification, gene disruption, and strain improvement. Synthetic biology for metabolic engineering.	
Learning Outcomes:	
	After completing this unit, the student will be able to • summarize mechanisms of regulation of metabolic pathways and networks (L2) • describe methods of metabolic engineering based on gene manipulation (L1) • describe application of synthetic biology for metabolic engineering (L1)
Unit- V	**6 hrs**
Calculation of theoretical yield. Amino acid production by glutamic acid bacteria, metabolic engineering of lactic acid bacteria, riboflavin production by Bacillus subtilis, metabolic engineering of Saccharomyces cerevisiae.	
Learning Outcomes:	
	After completing this unit, the student will be able to • list metabolomic databases (L1) • calculate theoretical yield of a reaction (L3) • apply metabolic control analysis (L2) • describe application of metabolic engineering in bacteria (L1) • describe application of metabolic engineering in eukaryotes (L1)
Course Outcomes:	
	After the completion of the course the student should be able to • describe methods for identification and quantification of metabolites (L1) • summarize methods for control of metabolic pathways (L2) • calculate flux control coefficients and theoretical yeilds (L3)

	• explain the principles of metabolic engineering (L4) • describe the applications of metabolic engineering (L1)
Text Books:	
	1. Eberhard Voit. A First Course in Systems Biology. Edition 2. Garland Science, 2017. 2. G.N. Stephanopoulos, A.A. Aristidou, J. Neilsen, Metabolic engineering. Principles and Methodologies, Academic Press, Elsevier, 1998.
References:	
	1. C .Wittman, S.Y.Lee (ed.), Systems metabolic engineering, Springer, 2012. 2. B.N. Kholodenko, H.V. Westerhoff (ed.), Metabolic engineering in the post-genomic era, Horizon bioscience, 2004.

METABOLOMICS AND METABOLIC ENGINEERING LABORATORY

Minimum of 5 experiments from the following:

1. Estimation of k_m of an enzyme
2. Estimation of V_{max} of an enzyme
3. Effects of enzyme inhibitors on enzyme kinetics: Competitive inhibition
4. Effects of enzyme inhibitors on enzyme kinetics: Irreversible inhibition
5. Metabolite identification from Mass Spectral data
6. Metabolite identification from NMR spectral data
7. Metabolic pathways models
8. Optimization of flux in a metabolic pathway

MODELLING AND SIMULATION IN BIOPROCESSES

Bioprocess mathematical modeling involves the modeling of the dynamic changes of the metabolic rates and their distribution inside the cells with the changes of time and cultivation conditions, as well as the modeling of the dynamic changes of the reaction rates and mass transfer rates as well as the cultivation conditions inside the cell. This course focuses on the principles of process design and analysis of biochemical reactors. These designed reactors are applicable in the production lines of pharmaceutical, biotech and chemical industries.

Course Objectives:

- To study the modeling & simulation techniques of biochemical processes and to gain skills in using process simulators.
- analysis and interpretation of data
- Use research-based knowledge and research methods including design of experiments
- to know the requirements for real time process analytics at the bioreactor
- Parameters involved in the bioprocess
- Simulation of bioprocess

Unit- I	**6 hrs**

Modeling of biological systems: Modeling principles, significance of modeling and simulation, model development from first principles. Modeling approaches for Biological systems - structured and unstructured systems; Compartment models (two and four); Deterministic and stochastic, segregated and unsegregated approaches for modeling structured systems. kinetic models on different approaches; product formation model; genetically structured models, modeling of extra cellular enzyme production.

Learning Outcomes:

At the end of this unit, the student will be able to

- Select appropriate bioreactor configurations and operation modes based upon the nature of bioproducts and cell lines (L3)
- strong foundation about bioreactor design and scale-up. (L4)
- identify problems and seek practical solutions for large scale implementation of Biotechnology (L3)
- Understand modeling and simulation of bioprocesses so as to reduce costs and to enhance the quality of products and systems. (L5)

Unit- II	**6 hrs**

Modeling of diffusion: Bioprocess modeling: Modeling of continuous sterilization of medium; Models for external mass transfer, internal diffusion and reaction within biocatalysts, model for SCP production from spent sulphite liquor, model for antibiotic formation; modeling of therapeutic protein production with recombinant cells. Modeling of activated sludge process with a control system; model for anaerobic digestion.

Learning Outcomes:

- Create, select and apply appropriate techniques, resources for modeling (L3)

- prediction and modeling to complex engineering activities with understanding of the limitations of process (L4)
- Apply the knowledge of mathematics, science, engineering fundamentals to solve complex engineering problems. (L3)

Unit- III	**6 hrs**

Bioreactor modeling: Ideal and non-ideal bioreactors; stirred tank models; characterization of mass and energy transfer distributions in stirred tanks, tower reactor model; flow modeling, bubble column flow models, mass transfer modeling, structured models for mass transfer in tower reactors, process models in tower reactors, airlift models, modeling of non-ideal behaviour in bioreactors-tanks-in-series and dispersion models.

Learning Outcomes:

- analyze physical and chemical phenomena involved in various process. (L3)
- develop mathematical models for various chemical processes. (L3)
- use various simulation approaches. (L4)
- Simulate a process using process simulators(L5)

Unit- IV	**6 hrs**

Linear system analysis: Study of linear systems, linearization of non-linear systems; Software based simulation of linear models; Parameter estimation and sensitivity analysis; Steady state and unsteady state systems; stability analysis; Case study of recombinant protein production (Insulin). Simulation techniques (Software): continuous system simulators; dynamic process simulators; steady state material and energy balance programs.

Learning Outcomes:

- Understand the importance of modeling and dynamics in process control (L2)
- Distinguish first order and higher order systems. (L4)
- Derive modelling equations for various systems. (L5)
- Predict the responses of systems for common forcing functions. (L6)

Unit- V	**6 hrs**

Hybrid and other modeling techniques: Simulation techniques (numerical methods): Programs based on numerical methods like algebraic equations, Newton_ Raphsonmethod for algebraic convergence, interpolation arbitrary function generation. Programs based on solution of differential equations: Euler method for 1st and 2nd order integration; Fourth order Runga -Kutta method: stability of numerical integration, variable slip size method. Case studies, numerical problems. Advanced modeling techniques such as fuzzy logic, neural network, hybrid systems and fuzzy logic systems; case studies.

Learning Outcomes:

- Familiarize the students with numerical methods of solving the non-linear equations (L3)
- find approximate roots of the an equation by using different numerical methods (L3)
- apply Newton’s forward and backward formulae for equal and unequal intervals (L3)
- find integration of a function by using different numerical methods (L3)
- inference based on small and large sampling tests using statistical methods (L4)

Course Outcomes After the completion of the course the student should be able to • Understand the kinetics of enzymatic reactions • Assess / Evaluate the tools and techniques for design of bioprocesses • Apply basic programming tools for the modeling of enzymatic/microbial phenomena • Analyze biochemical processes • Visualize results obtained through modeling • Model a bioreactor	
Text Books:	
	1. B.W.Bequette, Process Dynamics: Modeling, Analysis and Simulation, Prentice-Hall, 1998. 2. Said S.E.H. Elnashaie, P. Garhyan, Conservation Equations and Modeling of Chemical and Biochemical Processes, Marcel Dekker, Inc., 2003.
References:	
	1. I.J. Dunn, Biological Reaction Engineering: Dynamic Modelling Fundamentals with Simulation Examples, Wiley-VCH, 2003

MODELLING AND SIMULATION IN BIOPROCESSES LABORATORY

At least five of the following experiments:

1. Bioreactor model to demonstrate effect of stirring speed
2. Bioreactor model to demonstrate effect of aeration rate
3. Modeling of Bioreactor tanks-in-series
4. Structured model for a tower reactor
5. Simulation of population growth in bacteria
6. Model of pharmacokinetics of a drug

MOLECULAR DIAGNOSTICS

Course Objectives:	
	• To learn methods for isolation and sequencing of nucleic acids • To learn molecular techniques useful for molecular diagnosis and prognosis • To learn methods for molecular diagnosis of common genetic disorders • To learn methods for molecular diagnosis of cancer and infectious diseases • To learn quality control and quality assurance for molecular diagnosis
Unit- I :	**6 hrs**
Isolation of DNA from Buccal swabs, Blood, Urine and Hair. Methods for DNA and cDNA amplification. Next generation DNA sequencing technology. Lab-on-a-chip approach to molecular diagnostics.	
Learning Outcomes:	
	At the end of this unit, the student will be able to • Learn the selection of the methodology for isolation of DNA (L1) • Amplify the DNA (L2) • Sequencing the DNA and next generation sequence technologies (L2) • Importance of lab on a chip (L2)
Unit- II:	**6 hrs**
Molecular techniques: Southern, Northern, Western, Dot and Slot Blots. PCR-RFLP, RT-PCR, multiplex-PCR, SSCP, CSGE, DGGE, DNA sequencing through mass spectrometry.	
Learning Outcomes:	
	At the end of this unit, the student will be able to • Learn the molecular techniques related to the diagnosis • DNA sequencing through mass spectrometer • Sensitive PCR amplification methods for DNA • Separation of DNA by electrophoresis
Unit- III	**6 hrs**
Genetic Disorders and classification of genetic disorders, single gene disorders (Cystic Fibrosis, Marfan's syndrome), multifactorial disorders (diabetes, Atherosclerosis, Schizophrenia). Molecular basis of cancer: gene expression analysis for tumor profiling. Molecular diagnostics for hematopoietic disorders. Molecular diagnosis for cervical cancer.	
Learning Outcomes:	

	After completing this unit, the student will be able to • evaluate marine biodiversity (L5) • explain the methods of conservation of marine environment as well as organisms(L2) • Percieve the potential of marine food web.(L5)

Unit- IV	**6 hrs**
Disease identification and genetic tests for following disorders: thrombofilia, cystic fibrosis, Huntington disease, fragile-X syndrome, thalassemia, sickle cell anemia, Alzheimer's disease, Huntington's disease, hepatitis C virus, cytomegalovirus. Molecular diagnostics for streptococcus and tuberculosis. Molecular diagnosis for HLA typing.	
Learning Outcomes:	
	After completing this unit, the student will be able to • appraise the potential of marine organisms in terms of natural products(L5) • identify chemicals and bioactive compounds useful in medical and research applications(L3) • explain the importance of enzymes for industrial applications(L2)
Unit- V	**6 hrs**
Quality control and quality assurance: identification and standards for molecular diagnosis. Regulatory issues in molecular diagnostics. Ethical considerations in molecular diagnostics.	
Learning Outcomes:	
	After completing this unit, the student will be able to • Explain the potential of marine biotechnology for economic development & to resolve environmental issues(L5) • outline the principles & processes of different aquaculture techniques(L2) • summarize the use of biotechnological approaches to develop transgenic marine animals and maintenance of health of cultured organisms. (L2)
Course Outcomes:	
	• Describe techniques useful for molecular diagnostics (L1) • Describe the molecular basis for genetic disorders (L1) • Describe molecular methods for testing of genetic diseases (L1) • Describe molecular methods for diagnosis of infectious diseases (L1) • Describe molecular methods to assist diagnosis of cancer, diabetes and cardiovascular disorders (L1)
Text Books:	
	1. C.A. Burtis, D.E. Bruns Tietz, Fundamentals of clinical chemistry and molecular diagnostics, 7/e, Saunders, 2014. 2. L. Buckingham, Molecular Diagnostics: fundamentals, methods and

	clinical applications, F.A. Davis Company, 2011.
References:	
	1. G.P. Patrinos, W.J. Ansorge, Molecular Diagnostics, 2/e, Elsevier publications, 2010. 2. W.W. Grody, R.M. Nakamura, F.L. Kiechle, C. Storm, Molecular diagnostics: techniques and applications for the clinical laboratory, 1/e, Academic press, 2009. 3. D.E. Bruns, E.R. Ashwood, C.A. Burtis, Fundamentals of molecular diagnostics, Elsevier-Saunders. 2007. 4. C.A. Burtis, D.E. Bruns, eds. Tietz Fundamentals of clinical chemistry and molecular diagnostics, 7/e, Saunders-Elsevier, 2015.

MOLECULAR DIAGNOSTICS LABORATORY

At least five of the following experiments:

1. Sample collection for PCR testing
2. Sample preparation for PCR testing
3. Demonstration of Polymerase Chain Reaction
4. Demonstrate reverse transcriptase Polymerase Chain Reaction
5. Diagnosis of Malaria
6. Diagnosis of Tuberculosis
7. Detection of Streptococcus
8. Diagnosis of dermatological diseases
9. HLA typing
10. Polymerase Chain Reaction based test for molecular marker of systemic diseases-1
11. Polymerase Chain Reaction based test for molecular markers of systemic diseases-2

MOLECULAR MODELING AND DRUG DESIGN

Quantum mechanics is the foundation for predictiction of the stability of molecules. Molecular mechanics enables us to evaluate the relative energies of different conformations of a molecule. Molecular mechanics and knowledge based methods can be used to predict the mode of binding and stability of protein-ligand complexes. This knowledge can be used to design drugs that bind to selected molecular targets. This course is an introduction to the principles and algorithms applicable for design of drugs.

Course Objectives:

- introduce the principles of quantum mechanical methods of molecular modeling
- introduce the principles of classical mechanical methods of molecular modeling
- introduce the principles of knowledge based methods of molecular modelling
- introduce the principles of conformational analysis of biomolecules
- describe the benefits and limitations in the application of molecular modeling for drug design.

Unit- I	**7 hrs**

Quantum chemistry for Modeling of small molecules: Postulates of Quantum Mechanics. Variation method and Time independent Perturbation theory. Ab initio methods for molecules: Hartree-Fock SCF method. Common basis sets. Semi-empirical methods. Huckel's molecular orbital theory.

Learning Outcomes:

At the end of this unit, the student will be able to

- demonstrate knowledge of the postulates of quantum mechanics (L1)
- understand the principles of the basic quantum chemical methods (L2)
- understand the principles of the the ab initio and semi-empirical methods (L2)
- select optimum basis set based on requirements of the application (L5)
- calculate energies and wavefunctions of small molecules using Huckels MO theory (L3)

Unit- II	**6 hrs**

Stability of biomolecular systems: The hydrogen bond. Hydrophobic effect. Solvation energy.
Force fields for molecular modeling: Functional form of a type one force field. Parametrization of a force field. Anharmonicity. Potentials of mean force. Common force fields for biomolecules.

Learning Outcomes:		
	At the end of this unit, the student will be able to • describe the factors affecting the stability of biomolecular systems (L1) • describe the functional form of a type one force field (L1) • understand the limitations of type one force fields (L2) • understand the methodology used for parametrization of a forcefield (L2) • select optimum force field based on requirements of the application (L5)	
Unit- III		**6 hrs**
Conformational analysis: Geometry optimization using steepest descent and conjugate gradients. Molecular dynamics. Simulated annealing. Conformational analysis of polypeptides: Ramachandran map and rotamer libraries. Comparative modeling of protein structure. *De novo* Protein structure prediction. Conformation and stability of polynucleotides.		
Learning Outcomes:		
	After completing this unit, the student will be able to • describe the methods for target identification (L1) • demonstrate knowledge of the desirable properties of small molecule drugs (L1) • understand the concepts related to quantification of similarity of molecules (L2) • use quantitative structure property relationships to predict properties of small molecules (L3) • demonstrate knowledge of databases for drug design (L1)	
Unit- IV		**5 hrs**
Target identification for drug design. Desired properties of small molecule drugs. Molecular descriptors. Distance and similarity of molecules. Quantitative structure property relationships. Introduction to databases for drug design and development.		
Learning Outcomes:		
	After completing this unit, the student will be able to • describe the methods for target identification (L1) • demonstrate knowledge of the desirable properties of small molecule drugs (L1) • understand the concepts related to quantification of similarity of molecules (L2) • apply quantitative structure property relationships to predict properties of small molecules (L3) • demonstrate knowledge of databases for drug design (L1)	
Unit- V		**6 hrs**

Ligand based drug design: Quantitative Structure Activity Relationships (QSAR). Pharmacophore analysis.
Receptor based drug design: Principles of receptor based de novo ligand design.
Rigid body molecular Docking. Flexible docking.
Scoring functions for predicting ligand-receptor binding.
Case study: Structure based design of non-peptide inhibitors specific for HIV1 protease.

Learning Outcomes:

After completing this unit, the student will be able to

- distinguish between the strategies for ligand based and receptor based drug design (L4)
- predict activity of small molecules using QSARs (L2)
- compare advantages and disadvantages of rigid body docking and flexible docking (L4)
- understand the applications and limitations of scoring functions for ligand receptor binding (L2)
- describe the progress in design of inhibitors for HIV1 protease (L1)

Course Outcomes:

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

- recall principles of quantum mechanics and molecular mechanics (L1)
- utilize computational methods to model molecules (L3)
- select optimum computational method for binding site prediction (L5)
- apply computational methods for predicting stability of protein-ligand complex (L2)
- design drugs (L6)

Text Books:

1. Andrew Leach. Molecular modeling: principles and applications. 2^{nd} ed. Pearson Education. 2001.
2. Atkins and Friedman. Molecular quantum mechanics. Oxford University Press. 5^{th} ed. 2011.

References:

2. Tamar Schlick. Molecular modeling and simulation: An interdisciplinary guide. 2nd Edition. Springer. 2010.
3. Jan H. Jensen. Molecular modeling basics. CRC press. 2010.

Molecular Modeling and Drug Design Laboratory

This laboratory course is designed to enhance the conceptual understanding of molecular modeling and provides hands on experience for molecular modeling and an introduction to ligand based drug design as well as structure based drug design.

Course Objectives:

This laboratory aims to

- Introduce the concepts of forcefields.
- Introduce examples of structure optimization
- Demonstrate utilization of QSAR for predicting properties of molecules
- Demonstrate the application of docking for estimating binding constants
- Demonstrate the applications of molecular graphics

1. Molecular graphics for virtual manipulation of molecules
2. Molecular graphics for visualization of protein-ligand interactions
3. Calculation of potential energy of a molecule
4. Structure optimization of a molecule
5. Generating 3D representations from 2D descriptions of small molecules
6. QSAR calculations
7. Molecular editor for ligand design
8. Comparative modeling of proteins
9. Rigid body docking
10. Flexibile docking

Course Outcomes:

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

- Utilize molecular graphics for visualization of biomolecules
- Utilize molecular graphics for visualization of biomolecular interactions
- Apply QSAR for predicting molecular properties
- Implement structure optimization for small molecules
- Utilize docking for prediction of binding modes and binding scores

Text Books:

1. Andrew Leach. Molecular modeling: principles and applications. 2nd ed. Pearson Education. 2001.

References

1. **Rasmol Reference Manual. https://www.umass.edu/microbio/rasmol/distrib/rasman.htm**

SYSTEMS BIOLOGY

Descriptions of biological systems generally begin with a description of the components of the system followed by details of interactions of each component with other components of the system. However, this bottom-up view cannot provide a complete perspective of complex systems such as cells and organisms. Systems biology provides a top-down perspective of the control mechanisms that are utilized in living beings for maintenance of homeostasis, development and complex responses to external stimuli.

Course Objectives:

The objectives of the course are to:

- introduce concepts of network motifs observable in biological systems (L1)
- explain feed forward loops and their relevance for optimal gene circuit design (L1)
- explore temporal expression programs by feed forward loops and study of network motifs in sensory transcription networks (L1)
- integrate motifs in signal transduction networks and developmental transcription networks (L3)
- introduce the principles of robustness in biological systems (L1)

Unit- I	**10 hrs**

Overview of control mechanisms at transcriptional, translational and enzyme level. Representation of biological networks. Network modeling tools. Modeling and analysis of metabolic networks. Constraint based modeling of metabolic networks. Flux balance analysis. Metabolic flux analysis.

Learning Outcomes:

At the end of this unit, the student will be able to

- represent biological networks using graphs (L1)
- describe methods for modeling of networks (L1)
- understand the principles of metabolic network modeling and analysis (L1)

Unit- II	**10 hrs**

Basic concepts of transcription networks: input functions - logic input function, multidimensional input functions. Dynamics and response time of simple gene regulation. Optimal gene circuit design: fitness function and optimal expression level under constant conditions, optimal regulation under variable conditions.

Learning Outcomes:

At the end of this unit, the student will be able to

- describe the input functions for transcription networks (L1)
- build a model for dynamics of simple gene regulation (L5)

	• understand the principles of optimal gene circuit design (L1)

Unit- III	**8 hrs**

Network motifs: negative auto regulation, positive auto regulation.

Feed forward loop network motif: structure of the feed forward loop gene circuit. Dynamics of Coherent type-1 feed forward loop and Incoherent type-1 feed forward loop.Biological relevance of feed forward loop types. Selection of the feed forward loop networkmotif.

Learning Outcomes:

After completing this unit, the student will be able to

- identify the network motifs in transcriptional regulation (L2)
- compare the advantages and disadvantages of positive and negative autoregulation (L2)
- describe the principles of the feed forward loop network motif (L1)
- model the dynamics of the coherent type-1 feed forward loop (L3)
- model the dynamics of the incoherent type-1 feed forward loop (L3)

Unit- IV	**8 hrs**

Single input Unit network motif. Generation of temporal expression programs by single input Units. FIFO temporal order by multi output feed forward loop. Network motifs in sensory transcription networks. Network motifs in developmental transcription networks: two node positive feedback loops for decision making. Network motifs in signal transduction networks.

Learning Outcomes:

After completing this unit, the student will be able to

- describe the principles of the single input unit network motif (L1)
- model the dynamics of the single input unit network motif (L3)
- model the FIFO temporal order of feed forward loops (L3)
- describe the network motifs in sensory transcription networks (L1)
- describe the network motifs in signal transduction networks (L1)

Unit- V	**8 hrs**

The robustness principle. Robust patterning in development. Self enhanced morphogen degradation. Adaptation in bacterial chemotaxis. Models for exact adaptation. Information processing using multi-layer perceptrons. Network motifs in the neuronal network of *C. elegans*.

Learning Outcomes:

After completing this unit, the student will be able to

- describe the biological importance of robustness (L1)
- describe models for patterning in development (L1)

	• describe models for adaptation (L1) • describe the motifs in neuronal networks (L1)
Course Outcomes:	
	After the completion of the course the student should be able to • recall concepts of network based modeling of biological phenomena (L1) • illustrate the types and properties of motifs in transcription networks (L1) • define the principles of gene circuit design (L1) • identify properties that lead to robust systems (L2) • describe examples of adaptive networks (L1)
Text Books:	
	1. Uri Alon, An introduction to systems biology. Design principles of biological circuits, CRC Press, 2006. 2. Markus W. Covert. Fundamentals of systems biology. CRC Press, 2015.
References:	
	1. Eberhard Voit. A First Course in Systems Biology. 2nd Edition. Garland Science, 2017. 2. 3. Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald. Systems Biology: A Textbook. Edition 2. John Wiley & Sons, 2016. 4. C. J. Meyers, Engineering genetic circuits, CRC Press, 2009. 5. M. Ptashne, A genetic switch: phage [lambda] and higher organisms, Cell Press, 1992.

PROTEOMICS AND PROTEIN ENGINEERING

Proteomic studies are used to characterize the complete set of proteins in a cell, tissue, organ or organism. Comparative proteomic studies are useful for identification of biomarkers for diagnostic applications, for elucidation of the function of proteins and to identify targets for drug design. Stability and enzyme activity can be improved by protein engineering. This course introduces the methods for characterization of the proteome and the methods and applications of protein engineering.	
Course Objectives:	
	• describe potential applications of proteomics • describe databases related to proteomics • describe the methods for proteomics studies • describe the methods of protein engineering • describe the applications of protein engineering
Unit- I	**6 hrs**
Expression Proteomics: Proteome characterization by DIGE, Mass spectrometry and High throughput protein sequencing. Protein chips. Structural Proteomics: Comparative modeling, Molecular Replacement for X-ray diffraction, NMR spectroscopy.	
Learning Outcomes:	
	At the end of this unit, the student will be able to • describe the methods for expression proteome characterization (L1) • explain the benefits and limitations of proteomics (L2) • describe the methods used in structural proteomics (L1)
Unit- II	**6 hrs**
Interaction proteomics: Phage display, yeast two hybrid and mass spectroscopy. Functional proteomics: Predicting function from sequence, structure and interaction data.	
Learning Outcomes:	
	At the end of this unit, the student will be able to • describe methods used in interaction proteomics (L1) • describe methods used in functional proteomics (L1) • explain the limitations of benefits of interaction proteomics and functional proteomics (L2)
Unit- III	**6 hrs**
Proteomics databases: protein sequence identification, protein expression data, protein structures, protein-protein interactions, protein function. Applications of proteomics: Biomarkers for diagnosis. Target identification in drug development.	
Learning Outcomes:	

	After completing this unit, the student will be able to • summarize information available in proteomics databases (L2) • identify sources of proteomics information (L3) • describe applications of proteomics (L1)

Unit- IV	**6 hrs**
Objectives of protein engineering. Reaction environment engineering. Chemical modification of proteins. Principles of directed evolution for protein engineering. Methods for library design and high throughput screening. Semirational and Rational design for protein engineering. Characterization of engineered enzymes.	
Learning Outcomes:	

	After completing this unit, the student will be able to • describe the methods for reaction environment engineering (L1) • describe chemical methods for engineering of proteins (L1) • describe genetic methods for engineering of proteins (L5) • summarize rational design methods for protein engineering (L2)

Unit- V	**6 hrs**
Engineering of DNA polymerase for PCR applications. Engineering of lipases and cellulases for biofuel production. Antibody engineering. Enzyme engineering for production of antibiotics. Enzyme engineering for degradation of xenobiotics. Protein engineering for biosensors.	
Learning Outcomes:	

	After completing this unit, the student will be able to • describe applications of protein engineering for bioanalytial applications (L1) • describe applications of protein engineering in environmental biotechnology (L1) • describe applications of protein engineering for biopharmaceutical applications (L1)
Course Outcomes:	
	After the completion of the course the student should be able to • describe methods for obtaining proteomic data (L1) • list applications of proteomics (L1) • summarize the methods used for engineering of proteins (L2) • describe applications of protein engineering (L1)
Text Books:	
	1. R. Twyman. Principles of proteomics. 2nd edition. Garland Science. 2013. 2. A.Rees M.J.E.Sternberg and R.Wetzel. Protein Engineering. Oxford

	University Press. 1993.
References:	
	1. S.R.Pennington and M.J.Dunn. Proteomics: From Protein Sequence to Function. Garland Science. 2001. 2. Stefan Lutz, Uwe Theo Bornscheuer. Protein Engineering Handbook. Vol. 3. Wiley. 2013 3. Uwe Theo Bornscheuer and Mathias Hohen. Protein Engineering. Humana Press. 2018.

PROTEOMICS AND PROTEIN ENGINEERING LAB

Session	Description of Experiments
1	Isolation of total Protein from bacteria or plants or blood
2	Estimation of total protein concentration using Lowry's method
3	Estimation of total protein concentration using Bradford's method
4	Estimation of total protein by using BCA method
5	SDS-PAGE: Application
6	Western blotting: application (Virtual) and data analysis
7	2D-PAGE: application (Virtual) and data analysis
8	MALDI-TOF MS: application (Virtual) and data analysis

APPLIED BIOCATALYSIS AND BIOTRANSFORMATION

Biocatalysts have the potential to catalyze a wide variety of reactions of industrial, pharmaceutical, agricultural and medical significance. They have the potential to enhance reaction rates in mild conditions at low cost using sources that are environmentally friendly. This course provides an overview of the different types of biotransformations, the sources the the biocatalysts as well as their current and potential applications.

Course objectives:

- To describe different types of biocatalysts and their applications
- To classify reaction types of microbial transformations
- To describe redesign of biocatalysts
- To describe commercial lipases and their applications
- To describe the biosynthesis and transformation of alkaloids

Unit- I	**9 hrs**
General usage of biocatalysts, fermentation and applied biocatalysis. Types of bioconversion reactions, procedures for biotransformations, use of cells and enzymes for biotransformation, genetic manipulations of organisms for biotransformation, Application of bioconversions.	
Unit- II	**9 hrs**
Reaction types for microbial transformations of steroids, microbial breakdown of sterol side chain. L-Ascorbic acid, Dihydroxy acetone from glycerol, Prostaglandins, Hydantoinases, Carbamoylases, catalytic antibodies, Acylases and peptidases, reaction of penicillin and cepharosporin substrates, protection of amino groups, accumulation of pesticides, pesticides as carbon source, conjugate formation.	
Unit- III	**9 hrs**
Nitrile hydratases and nitrilases, biotechnology of nitrile transformations, regio and stereo selective biotransformation of nitriles, commercial processes, search for novel nitrile biotransforming activities, redesign of existing enzyme by protein engineering, metabolic engineering by multistep biotransfornation, cyanide biotranformation.	
Unit- IV	**9 hrs**
Commercial lipases, properties and application of lipases, lipid or surfactant coated lipases, inter-esterification of fats and oils, enantioselective esterification by lipase, commercial application (food ingredients and enantiomerically pure chemical and pharmaceutical intermediates)	
Unit- V	**9 hrs**

Tropane alkaloid biosynthesis, microbial metabolism of tropane alkaloids, morphine alkaloid biosynthesis, transformation of morphine alkaloid by Pseudomonas putida M10, microbial transformation of heroin.
Text Books:

	1.A.J.J. Straathof, P Adlercreutz (Eds.), Applied catalysis, 2/e, Hardwood academic publishers, Taylor and Francis, 2005

Course Outcomes:

At the end of this course the student should be able to:

- Understand the significance of biocatalysts
- classify reaction types of microbial transformations
- discuss the engineering of biocatalysts
- list commercial lipases and their applications
- describe the biosynthesis and transformation of alkaloids

GENOMICS AND GENOME ENGINEERING

Genomic studies are used to characterize the nucleotide sequences that encode the genetic information of an organism. Comparative genomic studies are useful for identification of biomarkers for diagnostic applications, for elucidation of the function of genes and to identify targets for drug design. This course introduces the methods for characterization of the genome and the methods and applications of genome engineering.	
Course Objectives:	
	• To learn the concepts related to genome organization, epigenomics and comparative genomics • To learn the genomic organization and sequencing strategies of model organisms • To learn techniques for genome editing • To learn methods for molecular cell imaging and transcriptomics • To understand the concepts of metabolomics
Unit- I	**9 hrs**
Organization of genomes. Genome maps. Data mining and sequence acquisition. Polymorphism and structural variations. Genome wide association studies (GWAS). Epigenomics and comparative genomics. Genome dynamics and cytogenomics.	
Learning Outcomes:	
	At the end of this unit, the student will be able to • Understand the organization of the genome (L1) • learn the concepts related to genomics and applied genomics (L1) • learn about the genome wide association studies and their importance (L1) • Understand the applications of genomic engineering (L2)
Unit- II	**9 hrs**
Genome sequence determination and genome analysis of E. coli, Saccharomyces cerevisiae, C. elegans, Drosophila melanogaster, Arabidopsis thaliana and Homo sapiens. Applications of genomics in predictive medicine and forensics.	
Learning Outcomes:	
	At the end of this unit, the student will be able to • Genomes of model organisms (L2) • Genome sequence, assembly and annotation of model organisms (L2) • Importance of model organisms genome sequence (L2) • Genetic diversity of model organisms (L1)
Unit- III	**9 hrs**

Introduction to Genome Editing, DNA repair mechanisms, Methods used in genome editing technology ZFNs, TALENs, Introduction to CRISPR/ CAS technology and its applications, Transfection optimization for efficient gene editing		
Learning Outcomes:		
	After completing this unit, the student will be able to • Learn the concepts of genome editing (L3) • Techniques to perform genome editing (L2) • Concepts related to DNA repair (L3)	
Unit- IV		**9 hrs**
Fluorescent tagging of fixed and live cells, CRISPR-based DNA tagging, Quantitative and high-throughput single-cell image analysis, Chip-seq, RNA-seq, single-cell transcriptomics, guide RNA.		
Learning Outcomes:		
	After completing this unit, the student will be able to • Understand the types of molecular cell imaging • Learn about Single cell transcriptomics (L3) • Learn about DNA tagging (L3) • Understand the importance of guide RNA (L4)	
Unit- V		**9 hrs**
Applications of genome engineering in therapy, synthetic, developmental biology, human genetics and disease phenotyping, Ethical aspects and safety of genome engineering technology.		
Learning Outcomes:		
	After completing this unit, the student will be able to • Learn about applications of genome engineering (L5) • Role of genomic engineering in human genetics (L5) • Ethical issues related to genome engineering (L5)	
Course Outcomes:		
	After the completion of the course the student should be able to • Be familiar with concepts of genomics and genomic engineering • Be familiar with the techniques that are available for the genome engineering • Design CRISPR based editing tools for the target gene of interest	
Text Books:		
	S.B. Primrose and R.M. Twyman, Principles of gene manipulations and genomics,7/e, Blackwell publishing, Oxford, U.K. 2006.	
References:		

	1. T.A. Brown, Genomes, 3/e, Garland Science, 2006. 2. A.M. Campbell and L.J. Heyer, Discovering Genomic, Proteomics and Bioinformatics, 2/e, Benjamin Cummings, 2006.

NANOBIOTECHNOLOGY

Nanomaterials are materials that are restricted to nanoscale size in at least one dimension.

Nanoscience is the study of nanomaterials that have unique physical, chemical or biological properties due to their size. Nanobiotechnology utilizes the unique properties of nanomaterials for applications in medicine, agriculture and industry. This course is an introduction to the fabrication, characterization and biological applications of nanomaterials.

Course Objectives:

- describe the unique properties of nanomaterials
- describe the methods for synthesis and fabrication of nanomaterials
- describe the methods for characterization of nanomaterials
- create awareness of applications of nanotechnology
- describe the application of nanomaterials in novel biomedical devices and components

Unit- I	**9 hrs**

Structure and properties of C60, carbon nanotubes and graphene.

Size dependent properties: Size dependence of sedimentation rate, adsorption effects, scattering of light, absorption of electromagnetic radiation, magnetic and electrical properties. Cooperative transitions in biological systems: Zimm-Bragg theory for helix-coil transition in polypeptides

Learning Outcomes:

At the end of this unit, the student will be able to

- list novel allotropes of carbon (L1)
- understand the relationship between size and properties of nanosystems (L1)
- calculate the fraction of residues in helical conformation using a simple model (L1)
- predict potential applications of nanomaterials based on their unique properties (L4)

Unit- II	**9 hrs**

Production of nanomaterials: Top down & bottom up strategies.

Green synthesis of nanoparticles.

Self-assembly: Langmuir-Blodgett films. DNA origami.

Learning Outcomes:

	At the end of this unit, the student will be able to • describe the methods for production of nanomaterials (L2) • compare the strategies for production of nanomaterials (L2) • understand the principles of self-assembly (L1)

Unit- III	**9 hrs**
BioNanomaterial characterization: Electron microscopy. Scanning probe microscopy. Light Scattering. Optical tweezers. Surface plasmon resonance. Light scattering. X-ray diffraction.	
Learning Outcomes:	

	After completing this unit, the student will be able to • describe the methods for chracterization of bionanomaterials (L3) • compare the methods for chracterization of bionanomaterials (L3)

Unit- IV	**9 hrs**
Vectors for drug delivery: Liposomes, Micelles and viral capsids. Targeted drug delivery – Nanobioconjugates for receptor targeting and magnetic guidance. Controlled drug release. Nanomaterials for Biomedical imaging: Quantum dots, SPIONs Theranostics.	
Learning Outcomes:	

	After completing this unit, the student will be able to • describe the properties nanoscale drug delivery vehicles (L4) • compare the advantages and disadvantages of different type of drug delivery vehicles (L4) • describe nanomaterials used for biomedical imaging (L4) • describe the principles and applications of nanomaterials in theranostics (L4)

Unit- V	**9 hrs**
Diagnostics and Prognostics: Principles and applications of Nanoarrays and Nanofluidics. Nanopore sequencing of DNA. BioNanomechanics: NanoBiomotors. Mechanics of cilia and flagella. Nanobioelectronics: Nanowires based on DNA. Molecular transistors. Voltage gated ion channels.	
Learning Outcomes:	

	After completing this unit, the student will be able to • list the unique properties of nanobiomaterials (L1)

	• describe the applications of nanodevices (L5) • describe the principles and applications of nanopore sequencing of DNA (L5) • describe the structure and function of nanobiomotors (L1) • describe nanobioelectronic components (L1)
Course Outcomes:	
	After completing this unit, the student will be able to: • understand and explain the unique properties of nanomaterials (L1) • compare the methods for fabrication of nanomaterials (L2) • select optimum methods for nanomaterial characterization (L2) • compare drug delivery vectors (L2) • describe the applications of nanobioelectronics (L1)
Text Books:	
	1. C. M. Niemeyer and C. A. Mirkin. Nanobiotechnology: Concepts, applications and perspectives. Wiley, 2006. 2. C. A. Mirkin and C. M. Niemeyer, Nanobiotechnology II: More concepts and applications, Wiley-VCH, 2007
References:	
	1. T.Vo-Dinh, Nanobiotechnology in biology and medicine: methods, devices and applications, CRC, 2007. 2. Y Xie, The nanobiotechnology handbook, CRC, 2012 3. https://nptel.ac.in/courses/118107015

STEM CELLS AND TISSUE ENGINEERING

Stem cells play crucial roles in tissue regeneration and understanding their properties is necessary for tissue engineering applications.

Course Objectives:

- Introduce the concepts of self renewal and differentiation of cells
- Describe the role of the extra cellular matrix
- Describe the biomaterials for cell culture
- Introduce the concepts of scaffold design and fabrication
- Describe the bioreactors for tissue engineering

Unit- I	**9 hrs**

Basic biology of stem cells: Types and sources of stem cells with characteristics: embryonic, adult, cancer stem cells, induced pluripotent stem cells; signaling mechanisms of stem cell self renewal and differentiation.

Learning outcomes:
After completion of the unit, the student will be able to:

- Describe the characteristics of stem cells (L1)
- Describe the types and sources of stem cells (L1)
- Describe the signaling mechanisms that are unique to stem cells (L1)

Unit- II	**9 hrs**

History and scope of tissue engineering. Organization of cells into higher ordered structures. Composition and diversity of extracellular matrix, receptors for ECM molecules. Matrix molecules and their ligands. Preparation of ECM, biologic activities of ECM, scaffolds. Commercially available scaffolds composed of extracellular matrix. Cell differentiation and migration.

Learning outcomes:
After completion of the unit, the student will be able to:

- Understand the organization of cells (L1)
- Describe the molecular constituents of the ECM (L1)
- List the commercially available scaffolds composed of ECM (L1)

Unit- III	**9 hrs**

Biomaterials in cell culture: harvest, selection, expansion, and differentiation, cell nutrition, natural polymers in tissue engineering applications, biomaterial scaffold properties. Models as precursors for prosthetic devices, quantitative aspects, cell tissue mechanics. Mechano-chemical control of cell fate switching.

Learning outcomes:
After completion of the unit, the student will be able to:

- Describe natural polymer in tissue engineering applications (L1)
- Describe the models for prosthetic devices (L1)
- Understand the principles of cell tissue mechanics (L1)

Unit- IV	**9 hrs**

Scaffold design and fabrication: degradable polymers and bioceramics for tissue engineering. Principles of scaffold design. Scaffold fabrication technologies: foaming, sintered microspheres, solvent casting, phase separation, electro-spinning. Textile technologies for fibre and fabrics. Solid free form fabrication.

Learning outcomes:
After completion of the unit, the student will be able to:

- Describe bioceramics and degradable polymers for tissue engineering applications (L1)
- Describe the principles of scaffold design (L1)
- Describe methods for scaffold fabrication (L1)

Unit- V	**9 hrs**

Bioreactors for tissue engineering: 2D and 3D cell culture. Key functions of bioreactors in tissue engineering. Bioreactor design and development. Bioreactors as 3D in vitro model systems, bioreactors in clinical applications, tissue engineering of skin, bone, cartilage, nervous system, lung, liver and pancreas.

Learning outcomes:
After completion of the unit, the student will be able to:

- Describe principles of 2D and 3D cell culture (L1)
- Understand the functions of bioreactors in tissue engineering (L1)
- Describe bioreactors for tissue engineering applications (L1)

Text Books:

1. C.A. van Blitterswijk and P. Thomsen, Tissue engineering, Academic Press series in biomedical engineering, 2008.
2. R.P. Lanza, R. Langer, W.L. Chick, Principles of tissue engineering, 3/e, Elsevier Publishers, 2007.

References:

1. Donglu Shi, Biomaterials and Tissue Engineering, Springer publishers, 2003.
2. Peter C. Johnson and Antonios G. Mikos, Advances in Tissue Engineering, Mary Ann Liebert publishers, 2012.

Course Outcomes:

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

- Describe the concepts of self renewal and differentiation of cells
- Describe the role of the extra cellular matrix

	• Describe the biomaterials for cell culture • Understand the concepts of scaffold design and fabrication • Design bioreactors for tissue engineering

Synthetic Biology

Course Code	Course Title	L	T	P	J	S	C
XXXXXXXX	Synthetic Biology	3	0	0	0	0	3
Course Owner	Biotechnology	Syllabus version				1.0	
Course Pre-requisite(s)		Contact hours				45	
Course Co-requisite(s)	None	Date Approved				-	
Alternate Exposure	Coursera Courses						

Synthetic Biology is the design and production of novel sub-systems or entire organisms from biological or bioengineered components. It may involve metabolic engineering or genetic engineering to optimize existing biological systems. Or novel biological systems may be designed and created.

Course Objectives

Describe the genetic code and its variations

Describe model systems for Synthetic Biology

Explain the principles of genome design

Explain the strategies for genome synthesis

Describe the potential applications of Synthetic Biology

Unit I

Introduction to Synthetic Biology: Basic concepts of synthetic biology. Self-replicating systems. RNA dependent RNA polymerase. Synthetic genetic code. Minimal genetic code. Extended genetic code. Non-native nucleic bases. Non-native backbone.

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

Describe the properties of self-replicating systems

Describe the genetic code and its variations

Understand the benefits of non-native nucleic bases and non-native backbone

Unit II

Minimal nucleic acid polymerases. Minimal ribosome. Minimal genome. Minimal cell. Minimal microbes (specific example E.coli and Mycobacteria). Targeted deletion methods.

Semi-synthetic systems. Semi-synthetic microbes.

Learning Outcomes

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

Understand the concept of minimal systems

Describe semi-synthetic systems

Describe semi-synthetic microbes

Unit III

Genome design. Building blocks and structures. Temporal and spatial engineering. Design tools for synthetic biology. OPEN and CoDA selection systems.

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

Identify the building block of genome design

Understand the concepts of temporal and spatial engineering

Describe the design tools for synthetic biology

Unit IV

Genome synthesis strategies. Genome editing tools - Zinc finger nucleases, TALENs, CRISPR-Cas9. Genome assembly methods. Genome sequencing. Measurement of genetic output.

Learning Outcomes

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

Understand the concepts of genome synthesis

Describe Genome editing tools

Apply genome assembly algorithms

Unit V

Microbial cell factories. Potential applications of synthetic biology for production of biomaterials, biofuels and drugs. Potential applications of synthetic biology in medicine, food production and bioremediation. Regulation of synthetic biology for safety. Intellectual property rights for synthetic organisms.

Learning Outcomes

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

Describe the potential applications of synthetic biology

Understand the importance of regulation of synthetic biology for safety

Understand the concepts related to intellectual property rights for synthetic organisms

Text Book(s)

C. Smolke, S.Y.Lee, J.Nielsen, G. Stephanopoulos. Synthetic Biology: Parts, Devices and Applications. (2018). Wiley-VCH.

D. N.Nesbeth. Synthetic biology handbook. (2016). CRC Press.

References

Church, G and Regis, E. (2012). Regenesis: How Synthetic Biology will Reinvent Nature and Ourselves. Basic Books.

Pier Luigi Luisi, Cristiano Chiarabelli. Chemical Synthetic Biology. (2011) Wiley & Sons.

Gibson, D.G., 2014. Programming biological operating systems: genome design, assembly and activation. Nature methods, 11(5), pp.521-526.

Course Outcomes:

After completion of the course, the student should be able to:

Describe the genetic code and its variations (L2)

Explain the importance of model systems for Synthetic Biology (L2)

Understand the principles of genome design (L1)

Describe the strategies for genome synthesis (L1)

Describe the potential applications of Synthetic Biology (L1)

	POs												**PSOs**		
CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	3	3									1	
2	3	3	3	3	3									1	
3	3	3	3	3	3								1	1	
4	3	3	3	3	3									1	

	POs												**PSOs**		
5	3	3	3	3	3									3	1
Avg	3.0	3.0	3.0	3.0	3.0									1.4	1.0

1-Low, 2- Medium and 3- High Correlation

Biomedical Engineering

Course Code	Course Title	L	T	P	J	S	C
XXXXXXXX	Biomedical Engineering	3	0	0	0	0	3
Course Owner	Biotechnology	Syllabus version				1.0	
Course Pre-requisite(s)		Contact hours				30	
Course Co-requisite(s)	None	Date Approved				-	
Alternate Exposure	Coursera Courses						

Biomedical Engineering is the application of engineering principles, practices, and technologies to the field of medicine. Models of physiological systems assist in obtaining insights regarding their function and provide information for potential remedial action. A wide variety of instruments assist the medical practitioners in the acquisition of the data required for diagnosis. Methods developed in Information Technology and Computer Science are being adopted for development of Clinical Decision Support systems.

Course Objectives

Describe the physical and engineering properties of materials relevant for biocompatibility

Explain the concepts of stress and strain required for understanding the musculoskeletal system

Describe the rheological properties of the cardiovascular system

Introduce the principles of biomedical sensors and signal processing

Describe Datatypes and Databases for clinical decision support systems

Unit 1 Biomaterials — No of Hours : 9

Tissue-implant interactions for ceramics, metals and polymers. Biodegradable materials. Smart biomaterials.

Tissue engineering: Transformed human cell lines and their applications. Embryonic stem cells and adult stem cells; therapeutic applications of stem cells. Organ culture of skin.

Learning Outcomes

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

- Understand the interactions of tissues with implant materials L1
- Describe properties of biodegradable and smart biomaterials L1

- Explain the properties of embryonic stem cells relevant for therapeutic applications L2

Pedagogy tools:
Self-reading , Lecture

Unit 2 Biomechanics No of Hours : 9

Relationship between stress and strain. Local balance of mass, momentum and energy. One dimensional model of a skeletal muscle. Viscoelastic properties of muscles.

Learning Outcomes

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

- Calculate strain based on stress for simple problems L3
- Calculate mass, momentum and energy balances L3
- Describe a simple physical model of skeletal muscle L1

Pedagogy tools:
Self-reading , Lecture

Unit 3 Biological transport phenomena No of Hours : 9

Rheology of blood and the Casson equation. The Fahraeus effect. Molecular and macroscopic level control of blood oxygenation level: Hill equation, Oxygen transport in the Krogh tissue cylinder. Single compartment model of urea hemodialysis. Two compartment model for drug absorption.

Learning Outcomes

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

- Explain the physical basis of the Fahraeus effect L1
- Calculate oxygen transport rates using the Krogh tissue cylinger L3
- Analyze urea hemodialysis and drug absorption using simple models L2

Pedagogy tools:

Self-reading , Lecture

Unit 4 Biomedical Instrumentation No of Hours : 9

Biomedical sensors – physical measurements, biopotential measurements, blood gas sensors. Introduction to Bioinstrumentation design. Time varying signals. Active Analog filters. Biomedical signal processing. Biomedical Imaging.

Learning Outcomes

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

describe the principles of sensing used by biosensors for physical measurements
describe how blood gases are measured
describe different modalities used for biomedical imaging

Pedagogy tools:

Self-reading , Lecture

Unit 5 BioMedical Informatics No of Hours : 9

Data types used in computer aided diagnosis: physical examination, historical, in-vitro diagnostic, histopathological, genetic, nucleotide sequence and image data. Medical image databases and PACS. SNP and genomic databases. Genomic and SNP data for prognosis. Clinical decision support systems.

Learning Outcomes

After completion of this unit, the student will be able to
- classify the types of data that is used for computer aided diagnosis
- describe medical image databases
- explain the principles of clinical decision support systems

Pedagogy tools:

Self-reading , Lecture

Texbook(s)

1. M. Saltzmann. Biomedical Engineering. 2nd Edition. Cambridge University Press. 2015. ISBN- 978-1107037199

2. J. Enderle, J. Bronzino. Introduction to Biomedical Engineering. 3rd Edition. Academic Press. 2011. ISBN- 978-0123749796

Additional Reading(s)

1. C. Oomens, M. Berkelmans, S. Loerakker, F. Baaijens. Biomechanics. 2nd Edition. Cambridge University Press. 2018
2. R. L. Fourneir. Basic Transport Phenomena in Biomedical Engineering. CRC Press. 2018
3. Medical Informatics: Knowledge Management and Data Mining in Biomedicine. Volume 8 of Integrated Series in Information Systems. Ed. Hsinchun Chen, Sherrilynne S. Fuller, Carol Friedman, William Hersh. Springer Science & Business Media, 2006
4. Medical Informatics: Computer Applications in Health Care and Biomedicine. Ed. Edward H. Shortliffe, Leslie E. Perreault. 2nd Edition. Springer Science & Business Media, 2013

Course Outcomes:

1. Compare the physical and engineering properties of materials relevant for biocompatibility (L2)
2. Explain the rheological properties of the cardiovascular system (L2)
3. Analyze stress and strain relationships in the musculoskeletal system (L4)
4. Describe the properties of biomedical sensors (L1)
5. List Datatypes and Databases for clinical decision support systems (L1)

	POs												PSOs		
CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	3	3									1	
2	3	3	3	3	3									1	
3	3	3	3	3	3									1	
4	3	3	3	3	3									1	
5	3	3	3	3	3									3	1
Avg	3.0	3.0	3.0	3.0	3.0									1.4	1.0

1-Low, 2- Medium and 3- High Correlation

AI and ML for BioEngineers

Course Code	Course Title	L	T	P	J	S	C
XXXXXXXX	AI and ML for BioEngineers	3	0	0	0	0	3
Course Owner	Biotechnology	Syllabus version				1.0	
Course Pre-requisite(s)		Contact hours				45	
Course Co-requisite(s)	None	Date Approved				-	
Alternate Exposure	Coursera Courses						

The progress of modern biology and medicine is closely linked to acquisition and analysis of massive amounts of data. Machine learning and Artificial Intelligence have proven their ability to utilize available biological data to facilitate inferential studies. In addition, the tools of Machine Learning and Artificial Intelligence have the potential to assist in the design and synthesis of complex biomolecules, pathways, gene circuits and even entire organisms. This course starts with a review of the fundamentals of AI and ML and provides an insightful overview of the diverse applications of AI and ML in Bioengineering.

Course Objectives

• Explain the concepts of automated reasoning and planning (L2)
• Compare methods for machine learning (L4)
• Describe applications of AI & ML in biomedicine (L1)
• Explain the utility of AI & ML for protein structure prediction & drug design (L1)
• Describe potential applications of AI & ML for the synthesis of drugs and the design of living organisms (L1)

Unit 1 Artificial Intelligence No of Hours : 10

Intelligent agents and Expert systems. Knowledge representation. Automated Reasoning. Perception and Action. Planning.

Propositional logic. First order logic. Fuzzy sets, Fuzzy logic and Fuzzy inference. Fuzzy relations. Fuzzy relations between symptoms and diseases.

Learning Outcomes

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

- Understand the concept of Intelligent agents L1
- Understand the principles of automated reasoning and planning L1
- Predict diseases using fuzzy relations L3

Pedagogy tools:

Self-reading , Lecture

Unit 2 Machine Learning No of Hours : 10

Learning association, classification and regression. Nonparametric models. Principal component analysis. Support vector machines. Unsupervised clustering. Self organizing maps. Artificial Neural Networks. Rosenblatt's perceptron convergence theorem. Back propagation learning algorithm for multilayer feed forward Neural Network.

Learning Outcomes

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

- prove convergence for Rosenblatt's perceptron model L2
- calculate output of a small feed forward Neural Network with one hidden layer for specified values of architectural parameters and weights L5
- select optimal machine learning method L3

Pedagogy tools:

Self-reading , Lecture

Unit 3 Biomedical Applications No of Hours : 8

Diagnostics, Biometrics and Forensics. AI & ML for biomedical image recognition and classification. Clinical Decision Support systems based on Biomedical Images, Molecular markers and Genome sequence data. Computer assisted surgery. Smart prosthetics. Brain-Machine interface.

Learning Outcomes

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

- Understand utility of machine learning for Biomedical Image classification L1
- Understand the utility of machine learning for Biomedical marker analysis L1
- Describe the role of AI in clinical decision support systems L1

Pedagogy tools:

Self-reading , Lecture

Unit 4 Bioinformatics & Pharmacoinformatics No of Hours : 9

Applications of AI & ML in Structural Genomics and Functional Genomics. Machine learning for metagenomics. AI & ML for Protein function prediction, Protein structure prediction and Drug Design.

Learning Outcomes

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

- Understand the role of AI & ML in Genomics L1
- Understand the role of AI & ML in protein structure and function prediction L1
- Understand the role of AI & ML in Drug Design L1

Pedagogy tools:

Self-reading , Lecture

Unit 5 Synthetic Biology No of Hours : 8

AI & ML for retrosynthesis of drugs. Metabolic pathway engineering. Design & inference of signalling networks. Potential applications of AI & ML for gene circuits, Genomic engineering and Organism design.

Learning Outcomes

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

- Understand the utility of AI & ML in retrosynthesis of drugs L1
- Describe utility of AI & ML in studies of cellular pathways, networks and gene-circuits L1

- Understand the potential of AI & ML for Genomic engineering and Organism Design L1

Pedagogy tools:

Self-reading , Lecture

Texbook(s)

1. S.J.Russell and P. Norvig. Artificial Intelligence: A Modern Approach. 4th Ed. Pearson. 2020. 9781292401133. Units 1,2
2. S.O.Haykin. Neural Networks & Learning Machines. 3rd Ed. Pearson. 2019. 0131471392. Units 1,2
3. Data Analytics in Bioinformatics: A Machine Learning Perspective. Edited by R. Satpathy et al. Wiley. 2021. 978-1-119-78560-6. Unit-4

Additional Reading(s)

4. W.R. Hersh, R.E. Hoyt. Health Informatics: Practical Guide. Seventh Edition. 2018. 1387642413. Unit-3
5. C.G. Lambert, D.J.Baker, G.P.Patrinos. Human Genome Informatics. Elsevier Science. 2018. 9780128094143. Units 4,5

Journal(s)

1. Segler, M.H., Preuss, M. and Waller, M.P., 2018. Planning chemical syntheses with deep neural networks and symbolic AI. *Nature*, *555*(7698), pp.604-610,Unit-5
2. de Almeida, A.F., Moreira, R. and Rodrigues, T., 2019. Synthetic organic chemistry driven by artificial intelligence. *Nature Reviews Chemistry*, *3*(10), pp.589-604,Unit-5
3. Lipinski Celio F., Maltarollo Vinicius G., Oliveira Patricia R., da Silva Alberico B. F., Honorio Kathia Maria. Advances and Perspectives in Applying Deep Learning for Drug Design and Discovery. Frontiers in Robotics and AI.Vol. 6. 2019. Pp.108, DOI=10.3389/frobt.2019.00108

Website(s)

Course Outcomes:

1. Understand and apply the concepts of planning, logic and inference (L1)
2. Understand and apply the basic concepts of classification and decision theory (L2)
3. Describe applications of AI & ML in clinical decision support systems (L1)
4. Describe applications of AI & ML in Bioinformatics & Pharmacoinformatics (L1)
5. Describe applications of AI & ML in the design of biochemical synthetic pathways, metabolic pathways and gene circuits (L1)

	POs												PSOs		
CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	3	3									1	
2	3	3	3	3	3									1	
3	3	3	3	3	3									1	
4	3	3	3	3	3									1	
5	3	3	3	3	3									3	1
Avg	3.0	3.0	3.0	3.0	3.0									1.4	1.0

1-Low, 2- Medium and 3- High Correlation